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EXTRA-ALIMENTARY CAUSES OF ALIMENTARY FILLING DEFECTS[1]

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THE object of scientific medicine is to recognize disease processes early, which can be attained only by the intelligent application of precise methods. Biochemistry is an outstanding example, its usefulness being ever-expanding. It is interesting to deal with changes before they become ponderous, before they have attained weight and dimension.

The roentgenological method of examining the gastro-intestinal tract enables one to appreciate not only organic changes, but indirect signs, such as subtractions from or additions to silhouettes, spasms, fixations, redundancies, points of tenderness, etc.

In the phylogenetic development of the gut tube, there has come about a radical subdivision in morphology, physiology, and function; these subdivisions are intimately related and an affection of one tends to disorganize all.

The gall bladder, the liver, the pancreas, and the stomach are embryologically, anatomically, physiologically, and pathologically closely related and should be considered as one physiologic system. Because of the continuity and contiguity of these numerous structures it is quite necessary to recognize filling defects as of pathologic and non-pathologic significance. The filling defect is the basic roentgenological sign of morbidity and, because of simulants, great care should be exercised in its proper recognition.

Irregularities in outline are also important roentgenological manifestations, whether they be due to additions to or subtractions from the normal contour. Filling defects are subtractions, and these may be (*a*) first, organic; second, spasmodic; third, physiologic; (*b*) intra-alimentary or extra-alimentary.

Errors in technic are responsible for some apparent defects. Among the most frequent is the neglect of eliminating pressure of the spine on the gastric shadow because of failure to elevate the chest and hips of the patient. Assuming that proper technic is practised, this source of mistakes can readily be excluded.

The genuineness of a filling defect is portrayed by its persistence under all conditions during fluoroscopic examination, its unaltered position and contour after massage, its constance upon all films and successive examinations, and the lack of obliteration after the administration of antispasmodics. The permanence and actuality of a filling defect cannot always be determined by taking a few roentgenograms alone: occasionally many films are necessary. The fluoroscopic examination

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

is often invaluable, for the shadow can be observed at various angles and positions and with the application of manipulation and pressure, and with the effect of gravity an obscure point may become quite perceptible. Some absence of peristalsis will assist in differentiation.

The filling defect may correspond to a palpable mass, for in occasional instances tumor masses that elude detection at the physical examination are felt by the roentgenologist. Unevenness of outline and lack of symmetry are rather constant in true filling defects. Abdominal rigidity and tension, pressure of a deformed costal arch, ascites, ovarian cyst, or pregnancy may produce irregularities in the outline of the alimentary canal.

Faulty media in which the barium is not evenly distributed may be misleading. Gas in the colon or fecal matter in the adjacent bowel also may cause indentations; however, palpatory shifting will help to identify these. Abnormal ligaments, peritoneal adhesions or membranes may produce filling defects. Mention will first be made of non-pathologic filling defects.

Commencing at the oral opening, the first defect noticeable may be the esophageal indentation produced by the aortic arch, which is liable to be accentuated by the presence of aneurysm. The next irregularity is produced by the anatomic relation of the esophageal opening in the fornix of the stomach, accentuated or moderated by the angle of entrance. Sometimes the diaphragm produces an irregularity which is caused by the apposition of the cardia and the muscular interdigitations of the diaphragm. This has been noted especially in cases in which tight corsets have been worn.

The spleen is the next offender, the shadow produced being quite characteristic. The size and shape of this indentation will vary according to the size and shape of the spleen, the type of stomach, etc., along the greater curvature, and, in close approximation to the splenic defect we often have a gastric irregularity due to a gas-distended or feces-filled splenic flexure. Sometimes the lesser curvature presents a conformation due to large psoas muscles, and the usual exhibition associated with the abdominal aorta. Confirmatory diagnosis of aneurysm of the abdominal aorta can occasionally be made because undue gastric pulsation can be detected fluoroscopically. A physiologic kyphotic or lordotic spine may produce simulants of defects. The gastric shadow is sometimes affected by the pressure of the transverse colon or a filled hepatic flexure which may impinge on the pyloric region.

In some instances the gall bladder, either pathologic or non-pathologic, but especially the former, may subtract from the area of the pyloric region, particularly along the greater curvature. The third portion of the duodenum may show irregularities, as it passes over the spine. It often happens that a concentric arrangement of portions of the jejunum or ileum, especially the latter, will cause apparent filling defects of the adjacent bowels, especially misleading when a non-visualized mass is contained in the lumen of the intestines.

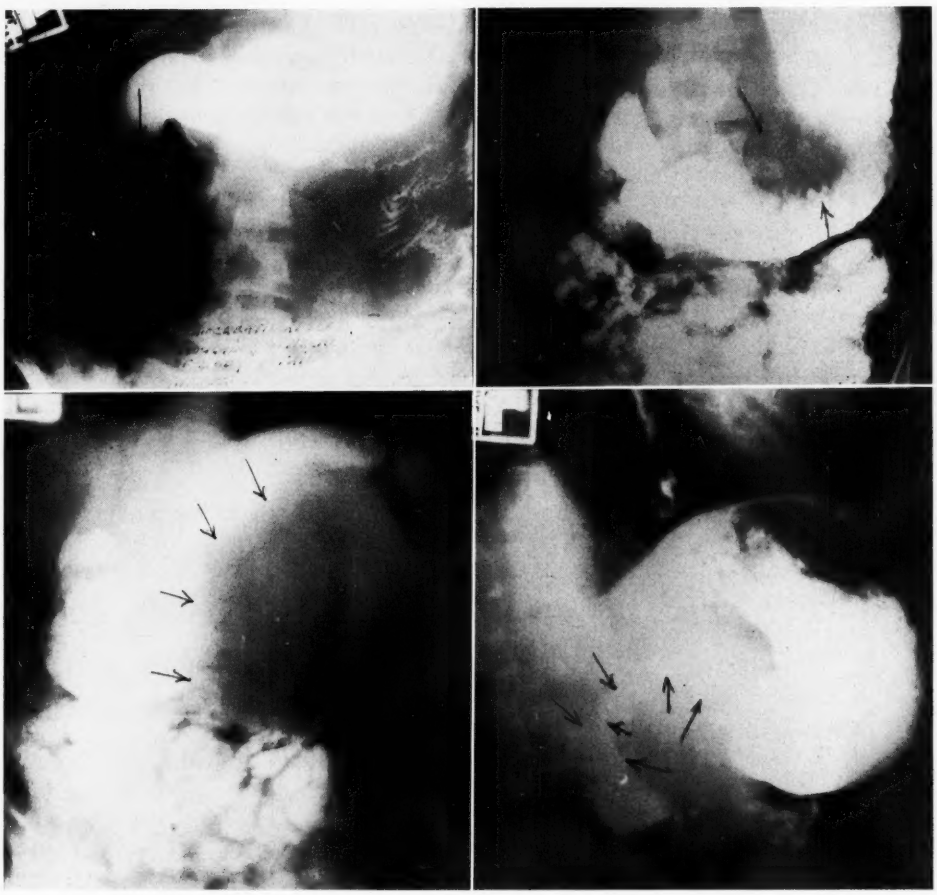
The terminal loops of the ileum are many times lifted above the iliopectineal lines by a filled cecum, sigmoid, and rectum or a distended bladder. The iliopectineal eminence often leaves its impress on the cecum or ascending colon as well as distorting the region of the junction of the ileac and pelvic colons.

It is quite impossible to embrace all or most of the phenomena in this brief outline, but the aforementioned conditions typify the usual probable sources of confusion, which can readily be recognized if anticipated. Among some of the pathologic conditions which produce filling defects are carcinoma, lymphosarcoma, splenomyelogenous leukemia, splenic leukemia, syphilis, varicosities, adhesions, and benign tumors such as uterine fibroids and ovarian cysts.

Since roentgenology is a branch of medicine, it should not confine itself to descriptive methods. All the manifestations observed should be transcribed into clinical and pathologic entities. Consequently the roentgenologist should require

all the pertinent data and subsequently should follow up the case to the point of finality. A tentative diagnosis is unsatisfactory.

With this premise in mind, the subjoined



Case 1 (*upper left*). B. K., pancreatic abscess with sloughing and necrosis of the body and the tail.
Case 2 (*upper right*). L. D., cyst in tail of pancreas.
Case 3 (*lower left*). A. Z., probably benign pancreatic cyst.
Case 4 (*lower right*). M. B., carcinoma in head of pancreas; gall bladder greatly distended.

citations are informative and the work-ups consistently thorough.

Case 1, B. K., female, aged 27 years.

History.—This patient was admitted to the Cook County Hospital on Aug. 5, 1937, complaining of epigastric pain and vomiting of three days' duration. This began as a sudden pain in her back, radiating to both lower quadrants. Vomiting, enemas, and bowel movements gave no relief. Pain was continuous and of increasing intensity up until the time of entrance.

Physical examination revealed a distended abdomen, with tenderness and resistance in both lower quadrants. Peristaltic sounds were absent. There was rebound tenderness noted at McBurney's point.

Laboratory Findings.—On Aug. 15, the red blood cells were 3,370,000, white blood cells, 22,750, polymorphonuclears 79, eo-

sinophils 1, basophils 1, lymphocytes, 14, monocytes, 5.

On Aug. 20, red blood cells were 3,070,000, white blood cells 11,650.

Urine was negative for albumen and sugar.

X-ray examination showed dilatation of the stomach by retained gastric contents. There was an extrinsic mass, causing pressure on the pylorus and the second portion of the duodenum, resulting in a high partial obstruction. Pancreatic tumor or cyst as well as mesenteric cyst had to be considered.

Clinical Diagnosis.—Acute bilateral salpingitis and pelvic peritonitis at first. Then considered were (1) infected pancreatic cyst and (2) infected horseshoe kidney.

Course.—The abdomen remained tender and distended and on Aug. 14, 1937, a mass was palpated in the epigastrium. The temperature was elevated, fluctuating from 100 to 103°. Exploratory operation was done on Aug. 27, 1937, and 3,000 c.c. of foul pus were drained from a pancreatic abscess. The patient expired on Aug. 28, 1937.

Anatomic Diagnosis.—(1) Pancreatic abscess, with sloughing and necrosis of the body and tail of the pancreas; (2) severe infectious hyperplasia of the spleen; (3) cloudy swelling and parenchymatous degeneration of the heart, liver, and kidneys; (4) recent laparotomy wound; (5) fat necrosis of the greater omentum, mesentery, and gastrocolic ligament; (6) cholelithiasis; (7) chronic salpingitis.

Case 2, L. D., male, aged 35 years.

History.—This patient was admitted to the hospital on June 13, 1938, complaining of epigastric pain of two months' duration. He was perfectly well up until two months previously, when he developed epigastric pain, which had its onset about 2 A.M. The pain was hunger-like in character and lasted a few minutes; relieved by milk or an eggnog. This pain also occurred during the day from one to two hours after meals and was relieved by milk.

The past history was essentially negative.

Physical examination revealed a well developed, well nourished, white male about 35 years of age who did not appear acutely ill. The essential findings were as follows: Head—Right pupil larger than the left; both reacted to light and accommodation. Neck—Essentially negative. Chest—Lungs clear; heart within normal findings. Abdomen, genitalia, extremities, and reflexes were essentially negative.

The impression was of peptic ulcer with hyperchlorhydria. It was necessary to rule out a carcinoma of the stomach.

Course and Work-up.—First barium meal on June 10, 1938, taken through the Admitting Department, revealed a filling defect in the pars cardia. The second barium meal, on June 15, revealed a large area of incomplete filling in the stomach indicative of an intragastric newgrowth, probably carcinoma.

Blood Examination.—Hemoglobin 70 per cent; red blood cells 4,500,000; white blood cells 7,000.

Stomach Contents.—The small meal showed free acid 0°; total acid 12°; combined acid 12°; mucus III; chemical blood. The feces were negative for blood. The urine was essentially negative. The patient continued to have post-prandial pain, and an exploratory laparotomy was advised.

He was explored on June 25, 1938, and a pancreatic cyst was found in the tail of the pancreas, displacing the stomach anteriorly. A pancreatico-cholecystostomy was done. The patient made an uneventful post-operative recovery and was discharged July 15, 1938.

Case 3, A. Z., male, aged 78 years.

History.—This patient was admitted to the hospital on June 8, 1937, complaining of pain and swelling of the abdomen for one year. He spoke Bohemian and it was difficult to elicit a history. It appeared he was apparently well until one year previously, when he began to notice a swelling of his abdomen. This progressively became larger and, as it did so, it also became very painful. In the last few weeks before ad-

mission he had become markedly constipated.

Physical Examination.—Temperature 98°; respirations 28; blood pressure 170/90.

Essential Findings.—Chest was hyperresonant and there were a few expiratory râles at both pulmonary bases. The heart was slightly enlarged and the tones were distant. There was a large mass, the size of a grapefruit, in the left upper quadrant of the abdomen. The prostate gland was somewhat enlarged. Differential diagnosis had to be made of (1) pseudo-pancreatic cyst; (2) retroperitoneal tumor, or (3) intragastric tumor.

Course and Work-up.—The urine was essentially negative. Stools were positive for chemical blood. Blood examination showed hemoglobin 65 per cent; red blood cells 4,380,000; white blood cells 7,550. The differential count was as follows: polymorphonuclear neutrophiles 60 per cent; polymorphonuclear eosinophils none; polymorphonuclear basophils none; lymphocytes 14 per cent; monocytes 6 per cent; stab cells 17 per cent; undifferentiated 3 per cent.

On a flat film of the abdomen, taken on June 9, there appeared to be a large mass in the left side of the abdomen. After a barium enema (June 15), a large extrinsic mass depressing the splenic flexure of the colon was seen. After a barium meal (June 18), a huge extrinsic mass, displacing the stomach upward and to the right, with pressure defect, was observed.

The genito-urinary work-up was essentially negative. A diagnosis of benign pancreatic cyst was made and an exploratory laparotomy suggested, but the patient refused surgery and was discharged on July 2, 1937.

Case 4, M. B., male, aged 49 years.

History.—This patient was admitted to the hospital on Oct. 4, 1937, complaining of loss of weight, polyurea, and a ferocious appetite. He had lost 50 pounds in weight.

Physical Examination.—There were no unusual findings. The urine contained sugar, diacetic acid, and acetone, and the diagnosis of diabetes mellitus was made. The patient was placed on management, and discharged under care of the diabetic clinic. He required protamine insulin 73 units daily.

This patient was admitted the second time to the hospital on Dec. 13, 1937, on which occasion he had jaundice of ten days' duration. Epigastric pain had been present for four weeks. Physical examination disclosed a nodular liver, tender and enlarged. The previous diagnosis of diabetes mellitus was reaffirmed and the additional consideration of carcinoma of the stomach added. He complained of "terrible backache" up the spine to the level of the shoulder blades. Differential diagnosis then included tumor of the head of the pancreas. Carcinoma of the bile ducts and common duct stone were also considered. Transfer to surgery was agreed upon.

At operation, "a carcinoma of the head of the pancreas was found. There was a huge mass covering the entire retroperitoneal area, with metastases to the liver. There was bile-stained fluid free in the peritoneal cavity. The gall bladder was greatly distended with bile." The operation done was cholecystogastrostomy, over a catheter. Following the operation the patient did not do so well, quickly developed a congestion of both lungs, was given oxygen and the usual therapy, but died on the second post-operative day.

Case 5, F. R., male, aged 30 years.

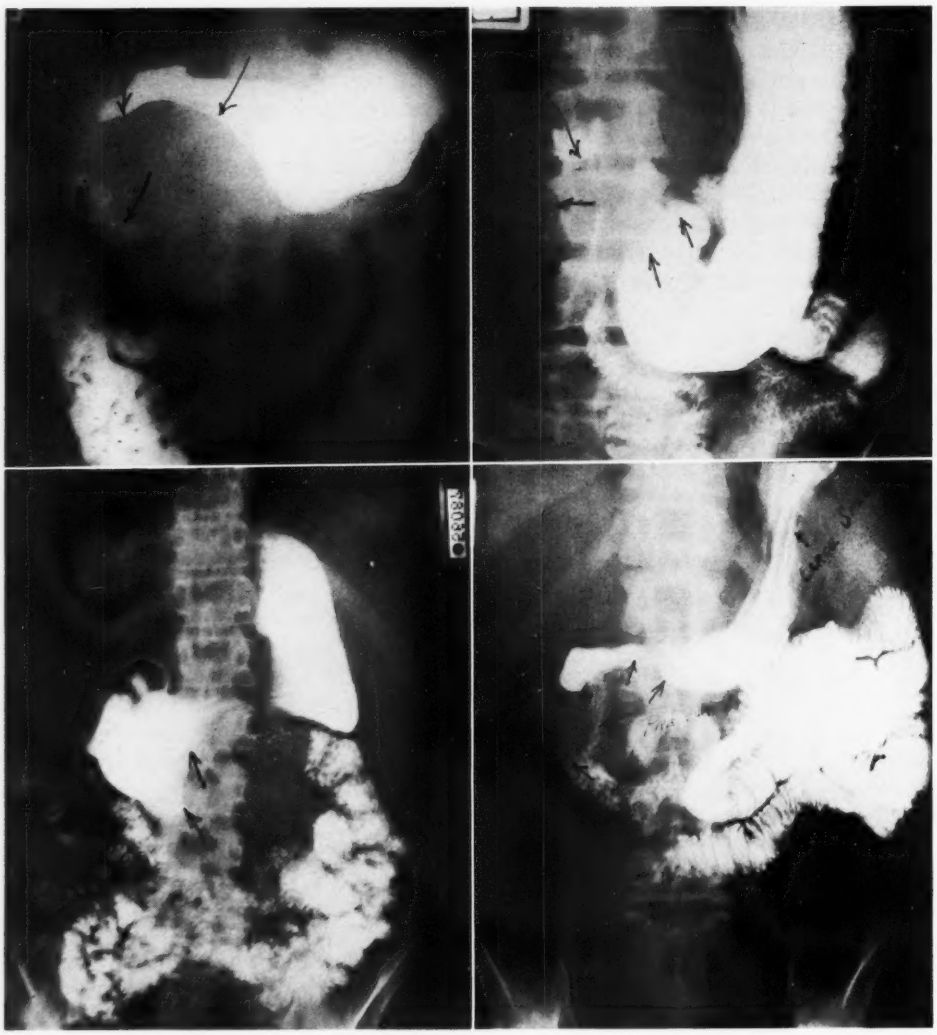
History.—This patient was admitted to the hospital on Oct. 22, 1931, complaining of a sudden severe pain in the epigastrium. The onset was without any premonition, while he was working—hanging and pasting paper. He compared the pain to a "sudden blow in his abdomen," and it lasted about forty-five minutes. Five days later he began to notice a swelling in his abdomen. This progressively became larger until the day of admission.

Physical Examination.—Temperature 97°; pulse 74; respirations 20; blood pressure 112/68. The patient was a white male, of Latin race, who did not appear

acutely ill. There was present a large mass in the abdomen—fairly firm, movable up and down. There was slight pain on pressure. Pulsation of the aorta was transmitted to the mass.

The heart was enlarged; presystolic thrill over the precardial area; diastolic and presystolic murmurs over the apex.

It was necessary to make a differential diagnosis between pancreatic cyst and rheumatic heart disease.



Case 5 (*upper left*). F. R., adenocarcinoma originating from aberrant-pancreatic tissue.
Case 6 (*upper right*). J. S., carcinoma of whole head and body of pancreas.
Case 7 (*lower left*). N. M., carcinoma of body of pancreas with cystic degeneration; spleen enlarged.
Case 8 (*lower right*). G. L., large gall bladder compressing stomach; common duct 4 cm. in diameter.

Course and Work-up.—The urine was negative. Blood chemistry showed urea nitrogen 13.4; blood sugar 67.0; icteric index 4.00; blood examination: red blood cells 4,759,000; white blood cells 8,500.

The barium meal revealed no apparent pathology in the stomach and duodenum. Stomach contents showed free acid 108, total acid 122.

The mass remained about the same size while the patient remained in the ward, and an exploratory laparotomy was advised. He was operated upon on Nov. 25, 1931, and a large aggregation of omentum was found over the pancreas, also a large cyst fluctuant posteriorly to the pancreas. Due to mechanical difficulty and the precarious position of the mass, no attempt was made to incise or isolate it. A barium meal (Nov. 18), one week prior to the operation, showed that the second and third portions of the duodenum formed a large "C" loop with some compression on the second portion resembling an enlargement of the head of the pancreas. The patient had a stormy convalescence and was finally discharged Jan. 21, 1932.

He was re-admitted to the hospital on Feb. 3, 1932, complaining of dyspnea on exertion, swelling of the ankles, and heaviness and fullness in the right upper quadrant.

Course and Work-up.—The stools were positive for blood. Blood chemistry—urea nitrogen 9.80, sugar 85.0. The blood Wassermann test was negative. A flat film of the chest revealed the mitral type of heart, showing moderate enlargement with passive congestion. EKG was negative. His condition progressively became worse until he expired on March 13, 1932.

Autopsy Findings.—Adenocarcinoma originating from aberrant pancreatic tissue and perforating into the third portion of the duodenum; metastasis to the liver; fibroplastic calcific deformity of the mitral valve with marked stenosis of the ostium; slight hypertrophy of the heart, with anemia and parenchymatous degeneration of the myocardium; anemia of the liver, spleen, and kidneys; marked edema of the lungs; bloody intestinal contents; slight edema of the legs.

Case 6, J. S., colored, aged 50 years.

History and Physical Examination.—This patient entered the hospital on Sept. 6, 1938, complaining essentially of pain in the epigastrium of two and one-half months' duration. There had been a loss of 32 pounds in weight; yellow discoloration of eyes and skin. Pruritus and nosebleeds, one month. Physical examination revealed a palpable hard globular mass in the right upper quadrant.

Course and Work-up.—the urine showed sugar 3 plus; bile plus; no urobilinogen repeatedly. Hemoglobin 85 per cent; red blood cells 4,840,000; white blood cells 6,650. The Ewald meal 25 free, 46 total HCl. Stools—3 plus blood repeatedly; negative for bile repeatedly. Blood chemistry, total protein 8.38; albumen 5.52; globulin 2.83; cholesterol 212; calcium 9.9; phosphorus 7.4. Wassermann test was negative. Icteric index, 99 Sept. 3, 1938; 150 Sept. 11, 1938. Glucose tolerance test, fasting 75, 166 at 30 minutes, 250 at one hour, and 214 at two hours.

On x-ray examination, the colon filled well, showing no pathology. There was no apparent pathology in the esophagus, stomach, or duodenum fluoroscopically. There was a round, extrinsic pressure defect in the region of the pylorus and the second portion of the duodenum, strongly suspicious of an extrinsic tumor mass, most likely carcinoma of the head of the pancreas.

The patient was operated on, on Sept. 26, 1938, a large tautly distended gall bladder containing 200 c.c. of dark bile being found. The extra-hepatic bile ducts were all distended. The pancreas was tremendously enlarged and nodular. The tumor occupied the whole head and body of the pancreas, pushing forward from below on the stomach and duodenum through the transverse mesocolon.

Pathological Report.—Squamous-cell carcinoma.

Case 7, N. M., colored female, aged 49 years.

History.—This patient was admitted to the hospital on June 16, 1938, her only complaint being persistent, severe, increasing pain in the left upper quadrant,

radiating to her back, for three months. This had no relation to meals or time of the day.

Physical Findings.—Essentially negative except for a firm mass, orange-sized, in the left upper quadrant. This was suspected of being a spleen or kidney tumor.

Course and Work-up.—The urine was negative; stools were negative for blood. Blood: hemoglobin, 75 to 85 per cent; red blood cells, 4,100,000; white blood cells, 2,200 to 3,500; no abnormal cells. Sternal puncture showed normal bone marrow. Blood repeatedly showed no material parasites. Wassermann test was negative. Cholesterol, 128. Pyelography on two occasions showed extrinsic pressure on the medial side of the left kidney.

X-ray examination of the colon on two occasions revealed no intrinsic pathology, but the splenic flexure was low. The heart was enlarged and of aortic configuration. The spine showed slight arthritic changes in the lumbar region. There was a round tumor mass causing extrinsic pressure on the greater curvature of the stomach. Among the possibilities to be considered were tumor or cyst of the pancreas, and, less likely, a mesenteric cyst. The first and second portions of the duodenum were dilated. Fluoroscopically, there was a definite cardiac enlargement.

Biopsy of a skin nodule revealed no evidence of leukemia, or cancer.

The patient was operated on, on Sept. 22, 1938, revealing body of pancreas occupied by a firm tumor 12 × 10 × 8 cm., cystic anteriorly.

Diagnosis: cancer of body of pancreas with cystic degeneration. The spleen was enlarged and soft.

Case 8, G. L., female, aged 42 years.

History.—The patient had been jaundiced for one and one-half years. There was pain in the right upper quadrant and epigastrium. There had been dark urine for 12 months; clay-colored stools for 13 months. Loss of weight, 55 pounds in one year. Swelling of right upper quadrant and epigastrium for eight months.

Physical Examination.—Essentially as follows: marked icterus; liver four fingers below the costal margin; gall bladder palpable.

Course and Work-up.—The blood Wassermann was negative; icteric index 80; Ewald meal free 18, total 47; urine analysis bile 4+; blood 0; urobilinogen 0; stool 4+, blood, one examination.

X-ray Examination.—Flat plate of the gall bladder was negative. Non-visualization of the gall bladder. Stomach, suspicious of head of pancreas; extrinsic pressure.

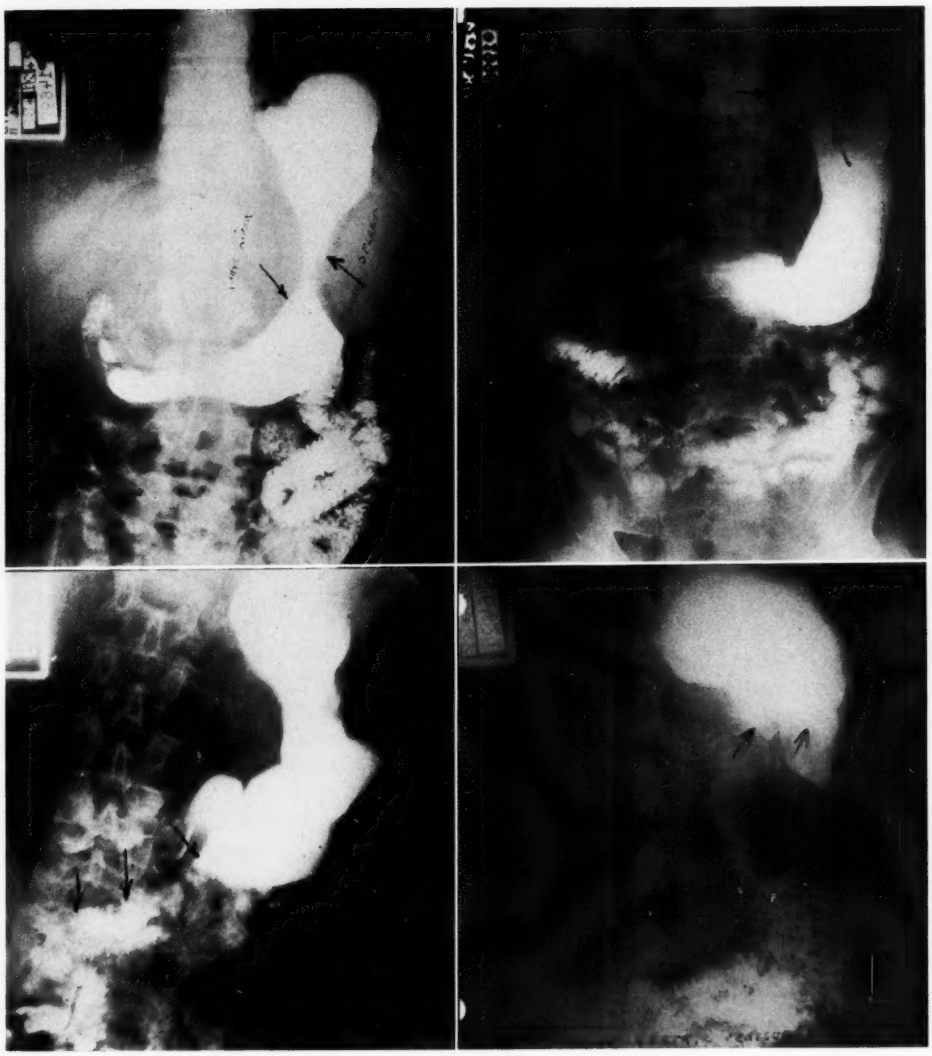
Surgery revealed a markedly dilated gall bladder compressing the stomach. The common duct dilated three to four centimeters. No tumor was felt in the head of the pancreas. Cholecystogastrostomy was done.

Case 9, C. C., male, aged 53 years.

History.—Patient was admitted to the hospital Feb. 18, 1938, complaining of loss of appetite, loss of 30 pounds of weight, and loss of strength of one month's duration. He had seemed perfectly well up until one month previously when he began to lose his appetite, strength, and weight. He also noticed that his stools had been black for the past week. Otherwise he had no complaints.

Past History.—Patient had had two attacks of severe abdominal pain, one five years previously, the other four years, situated in the epigastrium, knife-like in character, and had to be relieved by a hypodermic. He felt perfectly well the next day after each attack.

Physical examination revealed a well developed, well nourished, white male, who appeared pale. His temperature was 97.4; pulse 112; respirations 26; blood pressure 130/80. Essential findings were as follows: Tongue smooth and glossy; pupils reacted to light and accommodation; neck was negative; lungs clear; heart revealed systolic murmur over the apex. A large nodular mass, rather firm, filled the entire epigastrium; prostate was small and firm; extremities were negative; reflexes were physiological. An impression was gained of carcinoma of the stomach.



Case 9 (*upper left*). C. C., anaplastic fibrosarcoma of left pleura, with metastasis to liver and spleen; pulmonary, hilum, inguinal, peri-aortic, and right axillary lymph nodes.
Case 10 (*upper right*). E. W., adenocarcinoma of left lobe of liver, with invasion of stomach; sclerotic metastatic involvement of first lumbar body.
Case 11 (*lower left*). B. S., pedunculated cavernous hemangioma of left lobe of liver.
Case 12 (*lower right*). P. D'L., metastasizing glomangioma of the greater omentum.

Course and Work-up.—The urine was negative. The Ewald meal showed free acid 0, combined 10, total 10. Chemical blood III, mucus plus. Blood Wassermann was negative.

First chest x-ray examination, on Feb. 22, 1938, revealed a marked widening of the aortic shadow, probably due to an aneurysm. Examination with a barium meal was also done on Feb. 22, 1938, which revealed an extrinsic pressure defect of both the greater and lesser curvatures, believed

to be due to two soft tissue shadows, probably enlarged liver and spleen. A large tumor mass was also noted in the superior mediastinum. Fluoroscopy, done on Feb. 24, 1938, revealed an enlarged liver and spleen. The mediastinal tumor mass was also seen, and an aneurysm could not be ruled out.

The patient began to run a temperature while in the ward, ranging about 101.6°, and it was noted that his scleræ became icteric. His icteric index was found to be 18.00 on Feb. 28, 1938.

Blood Examination.—Hemoglobin 75 per cent; red blood cells 3,530,000; white blood cells 2,700; color index 0.7; differential count: polymorphonuclear neutrophils 86, polymorphonuclear eosinophils 0, polymorphonuclear basophils 0, lymphocytes 10 per cent, monocytes 4 per cent; anisocytosis, poikilocytosis, moderate; hypochromia, shift to the left of neutrophils, and a few neutrophils showed toxic granules. A provocative blood Wassermann on Feb. 28 was also negative. Stools were negative for blood on a meat-free diet.

On March 1, 1938, a gland was first felt in the left side of the neck and a probable Virchow's gland was suggested. This gland was removed for a biopsy, the pathologist's report (March 2) being that of a microscopic picture compatible with a late stage (stage of fibrosis) of a Hodgkin's lymphogranulomatosis.

The temperature curve was now interpreted as that described by Pel Epstein. The patient was put on x-ray therapy, improved, and was discharged on March 24, 1938, to be followed in the x-ray therapy clinic.

He returned to the hospital on June 20, 1938, because of increasing weakness, anorexia, and weight loss. The mass in the epigastrium (liver and spleen) was still palpable. The patient went downhill rapidly and expired on June 30, 1938.

An autopsy was performed and the findings were as follows: (1) Anaplastic fibrosarcoma of the left pleura with (2) metastases to the liver, spleen, anterior mediastinal, pulmonary, hilum, inguinal, peri-aortic, and right axillary lymph nodes; (3) metaplasia of bone in the metastases; (4) confluent bronchopneumonia of both lower pulmonary lobes; (5) parenchymatous degeneration and brown atrophy of the myocardium; (6) passive congestion and cloudy swelling of the kidney, spleen, and liver; (7) fatty changes in the liver; (8) aberrant pancreatic tissue; (9) hepatosplenomegaly; (10) jaundice.

Case 10, E. W., colored female, aged 57 years.

History.—This patient was admitted to the hospital on Dec. 9, 1936, complaining of loss of weight, weakness, and vomiting of two months' duration. Vomiting occurred ten minutes after eating, accompanied by severe pain upon which soda had no effect.

Physical Examination.—Temperature 98.2; pulse 94; respirations 24; blood pressure 226/140. The heart was enlarged and of aortic configuration. About the umbilicus there was a firm node.

The impressions gained were the following: (1) carcinoma of the stomach, (2) hypertensive heart disease, or (3) possible syphilitic aortitis.

Course and Work-up.—Red blood cells 1,700,000, free acid was present; blood Kahn test showed 4+; biopsy of umbilical mass revealed adenocarcinoma.

X-ray examination of the duodenum and stomach was negative, but an extrinsic mass was seen bulging into the cardia of the stomach. X-ray examination of the spine showed osteolytic and sclerotic changes on the tenth thoracic and first lumbar vertebral bodies.

Postmortem Findings.—(1) Adenocarcinoma of the left lobe of the liver with metastasis to the right lobe, space of Douglas, greater omentum, umbilicus, tracheobronchial and peribronchial lymph nodes and pleura of both lungs; (2) invasion of wall of stomach by the hepatic tumor; (3) hemorrhagic infarct of right middle pulmonary lobe; (4) slight left ventricular hypertrophy; (5) focal syphilitic aortitis; (6) intramural fibromas of the uterus; (7)

diverticulosis of the ascending and descending colon.

Case 11, B. S., white female, aged 73 years.

History.—This patient was admitted to the hospital on July 1, 1936, complaining of pain in the lower abdomen and a lump in the lower right abdomen of five weeks' duration. She had been apparently well up until five weeks previously, when she first noticed a painful hard lump in the right lower quadrant. She was constipated for a long time, having a hard bowel movement every two or three days, but in the last two weeks she had periods of diarrhea, having two to three bowel movements daily.

Past History.—In December, 1935, she sustained a fractured left femur.

Physical Examination.—Blood pressure 122/70; temperature 98; pulse 96; respirations 22. A poorly nourished white female appearing not acutely ill.

The essential findings in the head and neck were essentially negative. There was dullness in both bases of the lungs; breath sounds diminished at both apices; râles in right base. The left heart border was near the anterior axillary line: rhythm was irregular; systolic and diastolic murmur at apex radiating at axilla. Short systolic and diastolic murmur at aorta which did not radiate to the vessels of the neck.

In the abdomen the essential findings were tenderness in the left lower quadrant, large round mass in the right lower quadrant extending up to the right costal area—the mass was hard, smooth and fixed, and exquisitely tender. Peristaltic sounds were diminished.

In the extremities the peripheral vessels were markedly sclerotic. There was an old fracture of the right upper third of the femur.

Differential diagnosis had to be made from the following: (1) generalized arteriosclerosis withc oronary sclerosis; (2) auricular fibrillation; (3) possible carcinoma of the cecum, and (4) changes incident to senility.

Course and Work-up.—The urine was essentially negative. Blood examination showed hemoglobin 65 per cent; red blood cells 5,600,000; white blood cells 5,600. Icteric index 6.25; blood Wassermann was negative. Feces showed chemical blood II; fluid in character.

X-ray examination of the colon (July 6, 1936) showed distended rectal ampulla, but no pathology was noted. Graham-Cole examination (July 8, 1936) showed non-visualization of the gall bladder. There was marked osteo-arthritis of the lumbar spine. Examination by the barium meal (July 10) revealed a constant filling defect in the greater curvature of the pars cardia of the stomach, suggestive of carcinoma.

The patient's condition remained about the same. On July 14 the temperature rose suddenly to 107° axillary, she became cyanotic, respirations stertorous, and she went into coma. A heat stroke was suspected and she expired that day.

Autopsy Findings.—Pedunculated cavernous hemangioma of the left lobe of the liver; chronic suppurative cholecystitis; cholelithiasis; hypostatic pneumonia of right lower pulmonary lobe; moderate sclerosis of the coronary arteries and marked atheroma of the abdominal aorta; parenchymatous degeneration of the myocardium, liver, and kidneys; nodose goiter; adhesions between gall bladder, liver, and anterior abdominal wall.

Case 12, P. D'L., male, Philippino, aged 40 years.

History.—This patient was first admitted to the hospital on May 5, 1937, complaining of a painless mass present in his abdomen for six months. In January he noticed that he was jaundiced and that his stools were black. He admitted being a heavy drinker and that he had had gonorrhea in 1919.

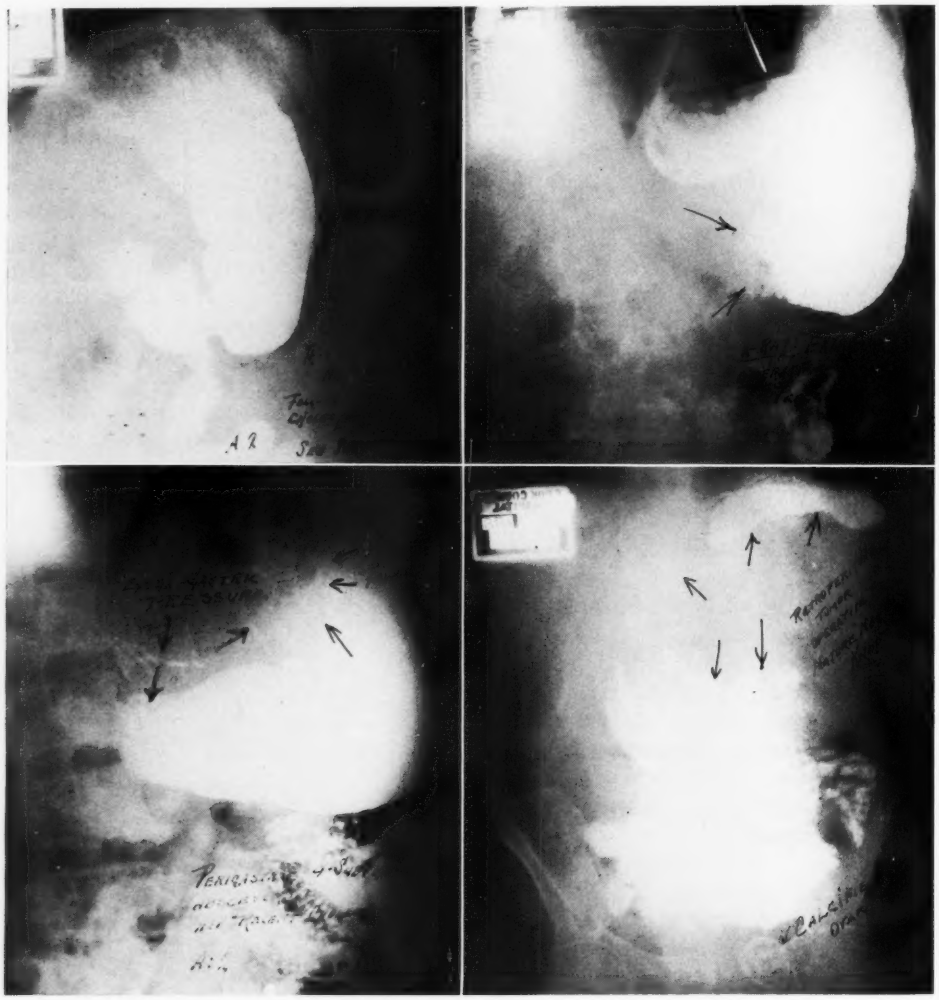
Physical Examination.—A well developed and well nourished patient. Temperature subnormal; pulse 72; respirations 20; blood pressure 150/100.

Essential Findings.—Scleræ icteric. Heart and lungs were negative. In the abdomen a large mass was felt which filled the entire right upper quadrant and ex-

tended down to the umbilicus. The mass seemed movable with respiration and the edge was smooth and sharp.

Icteric index 6.25; blood Wassermann test was negative.

An examination was made with thoro-



Case 13-*A* (*upper left*). M. C., negative stomach. (This preceded the cholecystectomy.)
Case 13-*B* (*upper right*). Cholecystectomy was done, with subsequent perigastric abscess.
Case 14 (*lower left*). Z. W., subphrenic and perigastric abscess on a tuberculous basis.
Case 15 (*lower right*). G. P., retroperitoneal tumor, probably fibrosarcoma.

Course and Work-up.—Hemoglobin 49 per cent; red blood cells 2,750,000; white blood cells 9,900; polymorphonuclears 88 per cent. Stools were positive for blood and grossly tarry. The urine was negative.

trast and the liver and spleen were well visualized and appeared within normal limits.

Further Course.—The patient was transferred in July to a surgical ward for an

exploration. The stomach appeared enlarged and an inoperable carcinoma of the stomach was considered. A biopsy was taken and was reported as a Schwannoblastoma.

The patient left the hospital only to return in September. This time he complained of weakness, shortness of breath, loss of weight, and enlargement of his abdomen. He appeared anemic and quite weak. Râles were heard in both pulmonary bases, and the liver was four fingers down; there was fluid present in the abdomen. The mass in the abdomen was slightly tender and large lymph nodes were palpable in the inguinal region.

X-ray Examination.—All the bones and chest were negative for metastasis. An abdominal paracentesis yielded 3,900 c.c. of amber-colored fluid, and microscopic examination showed large islands of degenerated cells. In the ward he had much abdominal pain from which he had relief after his abdomen had been tapped. He grew weaker and expired five weeks after his second admission, approximately one year after the onset of his illness.

Autopsy Findings.—(1) Metastasizing glomangioma of the greater omentum; (2) metastases to the mesentery, the parietal peritoneum, the wall of the stomach, the liver, and the right inguinal nodes; (3) brown atrophy of the myocardium and liver; (4) thorotrast pigmentation of the reticulo-endothelium; (5) ascites; (6) passive congestion of the lungs, spleen, and kidneys; (7) fibrous obliteration of the pleural cavities.

Case 13, M. C., colored female, aged 45 years.

Operated on for cholecystitis. Cholecystectomy done June 7, 1937. Ran postoperative low grade fever from 100 to 101° for three weeks, then began to have persistent vomiting, nausea, and anorexia. A mass was felt in the epigastrium four hours after operation. This mass felt reducible.

Operated on again six weeks after the first operation and perigastric abscess found. Methylene blue given by mouth was found on her surgical dressings. Expired seven days after second operation.

Case 14, Z. W., male, aged 46 years.

History.—This patient was admitted to the hospital June 22, 1937, complaining of a large mass in the abdomen of three months' duration. He was being treated for peptic ulcer. About three months previously, he noticed a small hard lump in the right upper quadrant. This lump grew progressively in size, gradually extending across and around the abdomen. The mass had become somewhat softer in consistence prior to admission.

Physical Examination.—Temperature 99.6; pulse 86; respirations 22; blood pressure 136/92. The essential findings in the head and neck were negative; the chest was symmetrical; the lungs clear; the heart had a systolic murmur over the apex. There was a large soft mass in the epigastrium and right upper quadrant, the size of a grapefruit; the liver was enlarged; the extremities were negative.

In making a diagnosis of echinococcus cyst of the liver, it was necessary to rule out amebic cyst and pancreatic cyst.

Course and Work-up.—The patient was proctoscoped on June 27, the findings being essentially negative. A barium meal on the same day revealed evidences of extrinsic pressure on the greater and lesser curvatures of the stomach, probably due to a large liver and spleen. Some evidence of a hiatus hernia was also noted.

In the ward, the mass became smaller and fluctuant. It was aspirated and no fluid was obtained. Since the patient ran a septic temperature and the mass persisted, an exploratory laparotomy was deemed advisable.

Stomach Contents.—The Ewald meal showed free acid 36 degrees, combined 14 degrees, total 50 degrees. The stools were essentially negative.

Blood examination showed red blood cells 2,760,000; white blood cells 12,200. Urine was essentially negative. Blood chemistry showed urea nitrogen 13.00. Blood Wassermann was negative. A barium enema

on July 12, 1937, showed that the colon filled well, showing no pathology.

The patient had an exploratory operation on July 24, at which a swelling was found in the epigastrium about the size of a grapefruit, in which there was a fluctuant area surrounded by a hard crater. A foul bloody purulent discharge was obtained. The abscess was drained. The patient continued to run a post-operative temperature, and the wound drained rather profusely. He gradually began to "lose ground" and go downhill. A biopsy from the abdominal wall on Sept. 4 revealed caseous tuberculosis. He expired on Sept. 16 with a terminal bronchopneumonia. The final conclusion since the chronic nature of the abscess was determined was a subphrenic abscess on a tuberculous basis.

Case 15, G. P., colored female, aged 48 years.

History.—This patient was admitted to the hospital on Feb. 9, 1938, complaining of one fainting spell, abdominal pain, upper abdominal distress, and constipation, all of three months' duration.

The patient had also been troubled with fullness after meals, pyrosis, and nausea for the same length of time. In that period she had lost her appetite and thirty to forty pounds in weight. She had had one fainting spell which she had been told was due to her high blood pressure. She had been told she had "bad blood" and had received twelve injections in the arm and twelve injections in the hip, at the end of which treatment she had been told her blood was negative. She was advised to continue treatment, but did not do so. During the past two months she grew weaker, and was confined to bed. In addition, she had difficulty in defecation and urination, and noticed shortness of breath with palpitation of her heart.

Past History.—Neuritis eight years previously; rheumatism, scarlet fever, and malaria as a child.

Physical examination revealed an extremely weakened colored female, lying quietly in bed, and appearing acutely ill. Temperature 99.4; pulse 80; respirations 48; blood pressure 190/106. The essential findings in the eyes were as follows: right pupil eccentric, small capsular fragments in right anterior chamber (previous operation); marked bilateral exophthalmos. The neck was essentially negative. The chest was markedly asthenic; breasts were atrophied; supra- and infraclavicular retraction. The lungs were clear. The heart, A-2, accentuated; systolic murmur heard best at the right second interspace. Examination of the abdomen showed dilatation of the veins of the scaphoid. There was a mass the size of an orange protruding from the left costal margin, which was firm, fixed, and somewhat tender. In the groin there was a bilateral, discrete, firm, non-tender inguinal adenopathy. The reflexes, genitalia, rectum, extremities, and pelvis were essentially negative.

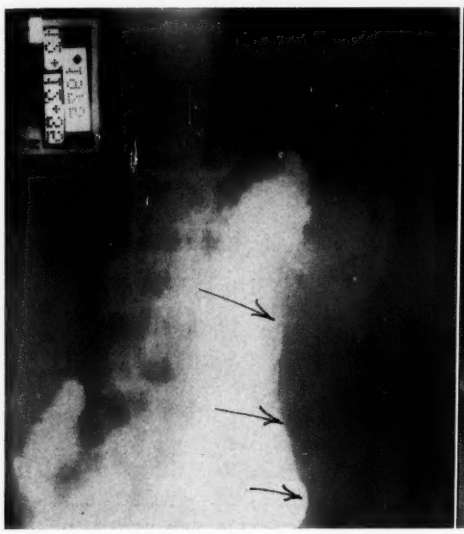
Impression.—Differential diagnosis had to be made among: (1) scirrhous carcinoma of splenic flexure; (2) secondary anemia, and (3) sarcoma originating from the left costochondral area.

Course and Work-up.—X-ray examination of the chest and abdomen on Feb. 11, 1938, revealed moderate increase in the hilar markings. The flat plate of the abdomen revealed a round area of varying degrees of calcification in the left pelvis which was believed to represent a calcified ovary. There was another small round area of density to the left of the left transverse process of the fifth lumbar vertebra. A barium meal (Feb. 23) revealed a large round palpable mass in the left upper quadrant causing extreme pressure on the stomach. Intravenous pyelogram (March 2) revealed considerable clubbing of the calices of the right renal pelvis.

Stomach Contents.—The Ewald meal showed free acid 0, total acid 10, combined 10. The feces showed chemical blood on two occasions.

Blood Examination.—Hemoglobin 55 per cent; red blood cells 5,200,000; white blood cells 5,100. The urine revealed many white blood cells and occasional hyaline casts. The blood Wassermann was negative. Aspiration biopsy of left costal

margin revealed no tumor cells. The mass remained about the same size and an exploratory laparotomy was advised. Operation was performed March 8, 1938, and a large retroperitoneal and retrogastric hard



Case 16. O. T., chronic myelogenous leukemia; large spleen.

Case 17. C S., ovarian cyst external to ascending colon.

mass found, well demarcated laterally, adherent posteriorly to the spine and to the abdominal wall in the region of the left kidney and adrenal—above the pancreas and below the spleen. No attachment to the stomach or colon was found. No peritoneal or liver metastasis was noticed. A fibrosarcoma was considered the most probable diagnosis. The patient made an uneventful post-operative recovery, was discharged on March 19, 1938, and referred for x-ray therapy.

Case 16, O. T., colored male, aged 51 years, occupation, worker in a steel foundry.

History.—This patient was admitted to the hospital Aug. 31, 1934, complaining of pain in the abdomen and a cough of seven months' duration; shortness of breath and swelling of ankles of three weeks' duration. He had seemed perfectly well up until Christmas, 1933, when he caught a cold and developed a dry hacking cough which persisted until the time of admission. At about the same time he developed a pain in the left upper quadrant, of a numb aching character. He had constipation of long standing. About three weeks before admission, for the first time, he became dyspneic and his ankles became swollen. These symptoms became progressively worse and he also developed attacks of nocturnal dyspnea. He had lost about thirty pounds in weight in the past six months.

Past History.—He had had a scrotal abscess incised. Gonorrhea and chancre, thirty years previously.

Physical Examination.—A fairly well nourished colored male, who appeared decompensated. Temperature 98.4; pulse 72; respirations 20; blood pressure 132/72.

Essential findings were: cervical and axillary (small) lymphadenopathy, with widened mediastinal dullness. The apex of the heart was enlarged to the left; systolic murmur and thrill at apex. The

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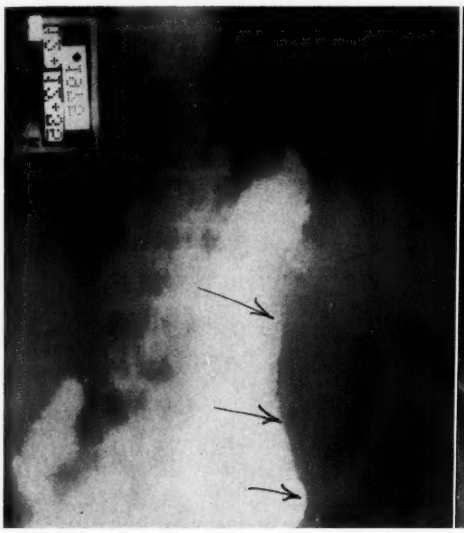

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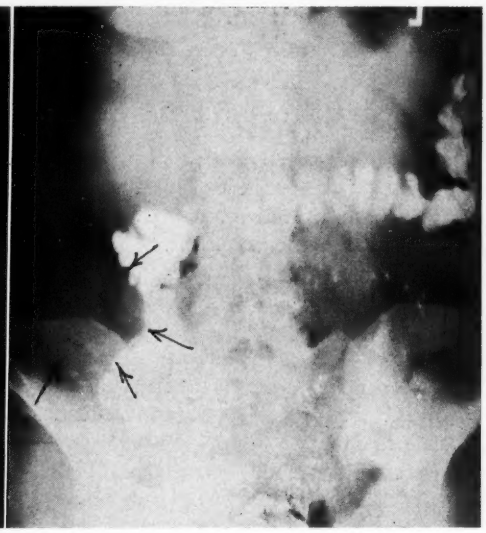

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Essential findings were: cervical and axillary (small) lymphadenopathy, with widened mediastinal dullness. The apex of the heart was enlarged to the left; systolic murmur and thrill at apex. The

liver was two fingers below the costal margin. The spleen was firm and a handbreadth below the left costal margin. The abdomen, slightly distended, contained no fluid. There was edema of the lower extremities.

Impressions.—(1) Leukemia—probably myelogenous; (2) rheumatic heart disease with beginning decompensation.

Course and Work-up.—Urine, bile II, otherwise essentially negative. Blood examination showed hemoglobin 46 per cent; red blood cells 2,860,000; white blood cells 197,400; color index 0.9; platelets 310,000. Differential count as follows: polymorphonuclear neutrophils 33 per cent; polymorphonuclear eosinophils 5 per cent; polymorphonuclear basophils 13 per cent; lymphocytes 3 per cent; abnormal forms—myeloblasts 9 per cent, myelocytes 13 per cent, metamyelocytes 17 per cent, red cells 7.5 per cent, normoblasts 2 per cent.

Blood Chemistry.—Urea nitrogen 14.50; uric acid 4.75; sugar 130.0; cholesterol 167.0. Blood Wassermann was negative; EKG showed evidence of minimal myocardial injury. Examination by barium enema showed that the colon filled well, showing no apparent pathology.

A diagnosis of chronic myelogenous leukemia with rheumatic heart disease was made and the patient was discharged Sept. 12, 1934, to be on x-ray therapy and iron and liver capsules. He was re-admitted to the hospital on Dec. 10, 1935, because he continued to lose weight and complained of pain in his abdomen.

Further Work-up at this Time.—Barium meal (Feb. 12, 1935) showed the mass on the left side believed to be spleen; the stomach was negative. A chest plate showed that the transverse diameter of the heart measured 60 mm. to the right of the midline and 90 mm. to the left. The contour was of the aortic type.

The white blood count returned to normal and he was discharged on Dec. 23, 1935, with x-ray therapy advised.

Case 17, C. S., white female, aged 32 years.

History.—Pain in the right lower quadrant, worse during menstrual period; had no relation to food; was intermittent, dull in character. Onset was gradual about four years previously. The past history was essentially negative.

Physical examination revealed a palpable mass in the right lower quadrant.

A gastro-intestinal x-ray series revealed a circular mass external to the ascending colon. Laparotomy revealed a pedunculated ovarian cyst.

Case 18, M. C., white female, aged 41 years.

History.—The patient had pain in the right upper quadrant, not related to food intake; occasional vomiting. She had experienced vague gastric disturbances for many years; occasional vomiting shortly after eating for several years past; no other relevant data.

Roentgenological Work-up.—Gastro-intestinal examination revealed a well-defined, smooth-bordered filling defect near the pylorus along the greater curvature, probably due to extra-gastric pathology.

Operation revealed a cyst of the omphalo-mesenteric duct.

Case 19, J. B., white male, aged 72 years.

History.—Loss of weight; no special gastro-intestinal symptoms; feeling of fullness in lower abdomen; frequent and unsatisfactory urination. The past history is essentially negative.

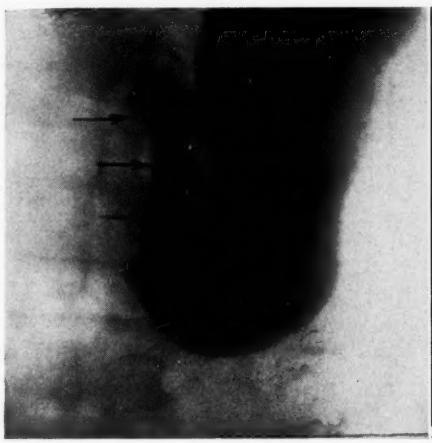
Physical Examination.—Pendulous abdomen; large palpable mass in suprapubic region, not tender to pressure.

Roentgenological Work-up. Six hours after the administration of a barium meal the jejunum and ileum were disclosed to be high in position and resting on some tumor mass, presumably fluid in content. Distended urinary bladder was suggested.

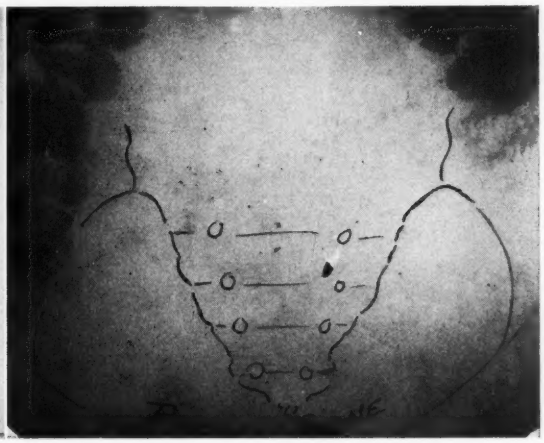
Subsequent Work-up.—Urine analysis showed no decomposition. Catheterization removed 39 ounces of residual urine, with disappearance of tumor mass. A large palpable prostate was present. Prostatectomy was done, with relief of symptoms.

Case 19-A, W. H., white female, aged 48 years.

History.—Difficult and unsatisfactory urination, intermittent in character, of about seven or eight years' duration, beginning more annoying for the last several years.



Case 18. M. C., cyst of omphalo-mesenteric duct.



Cases 19 and 19-A. J. B. and W. H. (2 cases), high position of small bowel due to marked retention of residual urine in bladder.

Physical Examination.—Well nourished individual; palpable mass in suprapubic region, fluctuant.

The roentgenologic findings were similar to those in the previous case.

Cystoscopic Examination.—This revealed an anomalous redundant fold of mucous membrane in the bladder, just above the ureteral orifice, which acted as a flutter valve. Catheterization removed a large quantity of urine, with total disappearance of the tumor. Separation of this membrane gave complete relief.

Note that both Cases 19 and 19-A were negative for syphilis. A neuropathic bladder had to be ruled out.

Case 20, B. S., white male, aged 60 years; occupation, custodian.

History.—This patient entered the hospital Nov. 28, 1937, complaining of urinary incontinence. He had been bothered with prostate trouble for the past 20 years. He had no sense of micturition and desired to urinate after voiding. He also had occasional hematuria. For the past two years he has had dyspnea, and some intermittent claudication.

Past History.—Had gonorrhea at the age of 30 years, and was being treated for syphilis at the time of admission. Three years previously he had had sudden paralysis of the left arm.

Physical Examination.—Temperature 98 degrees; respirations 18; pulse 72; blood pressure 190/110. Essential findings were Argyll Robertson pupils; neck negative; basal râles in the chest; heart enlarged, tones soft, and a systolic murmur at the apex; tambour A-2; abdomen scaphoid; liver one finger down; bladder distended; genitalia negative; rectal hemorrhoids and slightly enlarged prostate; rectum gapping; reflexes, exaggerated Achilles and plantars; extremities essentially negative.

Impressions.—(1) Central nervous system, syphilis; (2) benign prostatic hypertrophy; (3) organic heart disease. *Etiologic:* (1) arteriosclerosis; (2) hypertension; (3) syphilis. *Anatomic—cardiac enlarge-*

ment: (1) coronary sclerosis; (2) syphilitic aortitis. *Physiological*—decompensation. *Functional*—Class II B.

Case 20. B. S., marked cardiac enlargement, with pressure defect on cardia of stomach.

Case 21. J. W., abdominal aortic aneurysm.

Course and Work-up.—Spinal tap: Clear; pressure, normal; Pandy, negative; cells, negative; spinal Wassermann, negative.

Blood Examination.—Hemoglobin 56 per cent; red blood cells 3,740,000; white blood cells 9,950; color index 0.80; differential count: polymorphonuclear neutrophils 79 per cent; polymorphonuclear eosinophils 0; polymorphonuclear vasophils 1 per cent; lymphocytes 18 per cent; monocytes 2 per cent; anisocytosis, poikilocytosis and hypochromia. Stomach contents: Alcohol meal = free acid − 0; combined 4°. Feces: Showed trace of chemical blood. Urine: Albumin; occasional white blood cell. Blood chemistry: Urea nitrogen 61.00; creatinine 4.44. Blood Wassermann: Plus 3. Chest plate (Nov. 3, 1937): Revealed cardiac enlargement, and an undue prominence of the aortic arch. Increase of the hilar markings with calcification of the lymph nodes. There was an obliteration of the costophrenic angles. Cystoscopy: On Dec. 16, 1937, findings compatible with a diagnosis of trilobar prostatic hypertrophy and neurogenic bladder. Resection was advised, and the patient was transferred to the genito-urinary service.

Case 21, J. W., colored male, aged 65 years; occupation, carpenter.

History.—This patient was admitted to the hospital on Feb. 19, 1938, complaining of: (1) sickening pain in the abdomen; (2) sharp pains over heart, radiating to the left shoulder; (3) severe frontal headache (for two or three years); (4) dyspnea; (5) sharp pains over the heart radiating to the right shoulder (for two or three days). In 1924 this patient received a knife-stab wound in the abdomen to the right of the umbilicus. He was explored and had a long convalescence. He was told his liver was injured. In 1935, he began to get a "sickening, gnawing pain" in the abdomen which was accompanied by profuse vomiting and headache. In September, 1937, he

was in the Cook County Hospital for about a month, being discharged somewhat improved and referred to the clinic which he had been attending ever since.

Past History.—Measles and "yellow jaundice," malaria, pneumonia (twice), pleurisy, and gonorrhea (twice).

Physical Examination.—Revealed a colored male, in a fair state of nutrition, not acutely ill. Blood pressure 160/110 (in left and right arms); pulse 76; respirations, 20; temperature 98 degrees. Essential findings in the head were negative; in the neck, there were small glands in the right anterior. The chest was symmetrical. There were râles at the bases of both lungs. The heart was essentially negative. In the abdomen there was a right paramedian scar, with slight distention. A mass was palpable in the abdomen, extending from the epigastrium on the right side down to the pelvis—expansile and pulsating. The rectal sphincter was relaxed; the mucosa, redundant. The prostate, slightly enlarged. The genitalia, extremities, and reflexes were essentially negative.

Impressions.—(1) Abdominal aortic aneurysm on traumatic basis (consider a dissecting aneurysm); (2) coronary sclerosis; (3) cardiac asthma; (4) hypertension.

Course and Work-up.—Feces, one specimen plus chemical blood; urine, albumin III, bile I; blood Wassermann, negative; EKG, minimal amount of myocardial damage. X-ray examination of the abdomen and spine, Feb. 16, 1938, showed marked osteo-arthritis of the lumbar spine; no definite evidences of erosion. Examination by barium enema on Feb. 23, 1938, showed that the colon filled well, showing no pathology. Two days later, again by barium meal, a pulsating mass, extrinsic to the stomach and compressing it and the duodenum from below, was noted. The patient complained of marked night sweats while in the ward. He left the hospital of his own accord on Feb. 23, 1938.

THE LIMITATIONS OF INTRACAVITARY RADIUM THERAPY IN CANCERS OF THE CERVIX OF THE UTERUS[1]

By A. LACASSAGNE, M.D., *Paris, France*

From the Institute of Radium

DURING the first half of a period of almost 40 years, which separates us from the beginning of the radium therapy of cancer, the technic has varied but little. In the last twenty years, however, due, above all, to the possession of relatively large quantities of radio-active substances, rapid changes have taken place in the methods of their application. On the other hand, the development of x-ray apparatus of high voltages and the utilization of neutrons in therapeutics—still in the experimental stage—are methods of treatment of the future, the value of which has not yet been definitely determined.

The best guide for orientation should be the exact knowledge of the therapeutic results already attained. In an article entitled "The Place of Radium in Treatment of Cancer,"[2] the conclusion was reached that practically "the small curietherapy foci in the form of tubes, moulages, needles, etc., applied for superficial intracavitary or interstitial applications, seem destined to endure as long as the radiotherapy of cancer itself. They will persist, moreover, as an indispensable arsenal because of a varied action, at the same time very powerful and very localized, which only they can exercise."

On checking this statement, we will see the value of the local radium treatment of a quite common type of cancer, such as that of the cervix, for which the technic of application has for a long time been well established.

Table I shows strikingly the evolution that the method of irradiation of this type of cancer has undergone under the influence of the increase of radiotherapeutic material, at the Institute of Radium, in Paris.

It is apparent that for several years the intracavitary curietherapy was the only method employed, irrespective of the extent of the lesion, and was followed by a hysterectomy unless such an operation was contra-indicated. After several years, the radium-surgical combination was abandoned. It is no longer practised, save in a few cases of a special histological type, or because of conditions which render complete and thorough irradiation impossible. But, since 1923, in a greatly increasing number of cases, local radium therapy has been combined with x-ray therapy, and in 1924, with telecurietherapy, practised first with one, then with three, and then with four grams of radium (since 1934, with eight grams). The technic of combination of intracavitary radium therapy and transpelvic therapy, thus assumed first place. This change is apparent from the fact that of 404 patients, treated between the years of 1919 and 1923, 345, or 85 per cent, were treated only by local radium application; from 1924 to 1932, of 956 patients only 181, that is to say, 18 per cent, have undergone intracavitary curietherapy as the only treatment.

The years 1923 and 1924 thus mark an important change in the therapeutic methods of the Institute of Radium, in Paris. Until then, efforts had been, above all, directed toward the perfection of the intracavitary curietherapy. The technic of this method was perfected in 1922, and it may be said that no important changes have been made in it since then. However, if the results in these cases appeared to be satisfactory in the beginning, the benefits derived from the treatment of cases in Groups III and IV were mostly

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[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Lacassagne, A.: Canadian Med. Assn. Jour., **38**, 9, 1938.

transitory or even absent. The combination of local and external irradiation improved these results.

But this is not the subject of our discussion at this moment. We desire to study the rôle which the employment of a small tube of radium, introduced into the uterine or vaginal cavity, plays in the cure of cancer of the cervix. We shall consider, first, only those cases in which the cancer was apparently limited to the cervix, that is to say, those in Group I, treated by local curietherapy only, at the time when this technic of irradiation was definitely established (since the beginning of 1923). We shall analyze the results obtained after a review of at least five years which includes 79 patients treated up to the year 1932. But it is important to begin by recalling briefly the main points of the technic employed by the intracavitary curietherapy.

The tubes used measure 22 × 3.15 mm. or 4.15, depending on the thickness of the platinum filter, which was either 1 or 1.5 mm. These contain from 6 mgr.66 to 13 mgr.33 of radium. Usually the applicator which is introduced into the uterine cavity and occupies its entire length, consists of three tubes with a 1 mm. platinum filter, placed in tandem fashion in a rubber tube, thus representing a quantity of radium equal to 66 mgr.66. The application is made over a period of five days and corresponds to a dose of 8,000 mg. an hour. During the same time, or after the uterine application, the vaginal vaults are irradiated with three tubes with a 1.5 mm. filter enclosed in cork tubes 20 mm. in diameter. Two of them are held in place in the lateral *cul de sacs* by a special device and the third is applied to the cervical orifice. The quantity of radium which these contain is also 66 mgr.66. Thus the vaginal dose obtained by this arrangement in five days also amounts to 8,000 mg.-hours. Table II shows the results obtained in the 79 cases so treated.

The efficacy of this method of treatment is shown by the fact that 59 of the 79 cases treated may be considered as having been cured (74 per cent). In fact, 58 are actually living for from five to fourteen years, and one patient has died of cardiopathy at the age of 78, without any evidence of recurrence for six years.

There remains to be considered, 18 cases in which radium therapy failed, two cases having died without apparent recurrence, one of pulmonary tuberculosis two years after the treatment, and one of bronchopneumonia three years afterward. One patient was not seen after the treatment; she died of cancer one year later.

But it is interesting to analyze the 16 recurrences: (*A*) Four were localized to the cervix itself; (*B*) nine to the parametrium through lymphatic invasion, the uterus itself seeming to be free of involvement, and (*C*) three by distant metastases, though the pelvic examination did not disclose the cancerous localization.

TABLE I.—INTRACAVITARY CURIETHERAPY

Years	No. Patients Treated	Alone	Combined with Surgery	Combined with X-ray Therapy	Combined with Telecurietherapy	X-ray Therapy Alone	Telecurietherapy Alone
1919	103	93	10				
1920	98	97	1				
1921	48	42	5	1			
1922	69	62	2	1		4	
1923	86	51	6	17		12	
1924	80	22	5	34	7	12	
1925	97	13	5	27	35	6	11
1926	98	22	4	13	43	7	9
1927	110	22	1	18	44	21	4
1928	104	10	2	42	41	8	1
1929	117	15	2	42	49	5	4
1930	121	21	1	27	59	12	1
1931	113	22	1	24	57	6	3
1932	116	34	4	17	53	6	2

(*A*) *Local Recurrences.*—Three patients, in whom the recurrence appeared after four, five, and ten months, were hysterectomized; the operation did not prevent a new recurrence, which led to death after six months, eight months, and two and one-half years, respectively. The fourth patient had refused surgical intervention, when, 15 months after radium therapy, the recurrence became manifest. The disease spread slowly for two and one-half years.

(*B*) *Parametral Recurrences.*—These nine cases represent the most frequent type of recurrence. In six cases there were signs of compression, pain, or swelling of a limb, due to metastasis to external iliac or presacral glands. In three cases, the recurrence was disclosed by the loss of weight and the development of a tumor, placed high in the pelvic cavity and giving no signs of compression.

The dates of the appearance of the first sign varied from three months to three years, in seven cases. In two cases, a state of apparent good health had been maintained, in one for seven and one-half years and in the other for one and one-half years.

The x-ray therapy and telecurietherapy applied to several of these tumors were inefficacious. Death followed between five months and two and one-half years after the first signs of recurrence.

(*C*) *Extrapelvic Recurrences.*—In one case of a somewhat special histological form, the signs and the development of the disease led to an error in diagnosis. It was a cancer of the body of the uterus spreading to the cervix which, after a year of disappearance, produced a general metastasis, leading to death after six months, from foci in the liver, stomach, and brain.

The two other cases are more classic: in one, after three years of apparent cure, there developed an abdominal prevertebral tumor and in the other a vertebral metastasis appeared after four years.

TABLE II.—RESULTS OF CURIETHERAPY IN TREATMENT OF EPITHELIOMA OF CERVIX OF UTERUS

(Report on 79 Cases Treated from 1923 to 1932)

Years	No. Cases	Living without Recurrence	Dead, from Intercurrent Disease More Than Five Years after Treatment	Dead, from Intercurrent Disease Less Than Five Years after Treatment	Dead, from Complications Caused by Treatment	Dead, from Cancer; Cases not Seen after Treatment	Local Recurrences	Parametral Recurrence	Extrapelvic Recurrence
1923	8	6					1	1	
1924	4	3						1	
1925	7	5						2	
1926	4	4							
1927	9	7					2		
1928	4	2						1	1
1929	9	5	1	2				1	
1930	11	9						2	
1931	9	6				1		1	1
1932	14	11			1		1		1
Total	79	58	1	2	1	1	4	9	3

DISCUSSION

The necessity of treating the cases of inoperable cervico-uterine cancer, or those in the limit of operability group, by a total

irradiation of the pelvis, is now admitted by most radiologists. This method of treatment is best attained, at least at present, by local curietherapy combined with transpelvic radiotherapy. The increase in the number of cures obtained by this technic is shown by numerous statistics. We will not republish those of the Institute of Radium which appeared in the first paper published by the Organization of Hygiene of the League of Nations, dedicated to an inquiry on the results of radium therapy of cancer of the cervix of the uterus. We will limit ourselves to the statement that during the course of 10 years, from 1923 to 1932, the cures obtained by means of intracavitary curietherapy alone have been 38 per cent in Group II cases, 6 per cent in Group III cases, and none in Group IV cases. In contrast with these mediocre results of the local application, is the percentage of cures shown in the last statistics, established five years after the treatment. Based on the combined irradiation, the statistics show Group II, 53 per cent; Group III, 41 per cent, and Group IV, one cure out of the six cases treated. The great benefit of the combination technic is thus proved, as far as cancer of the cervix is concerned. Is it also true for cases of Group I? Here we lack the facts. It is only in the last few years that combined radiation has been applied to cancer limited to the cervix. It is still impossible to judge if after five years the proportion of cures will exceed remarkably the 75 per cent obtained by curietherapy. In reference to this method, it is, however, important to appreciate the considerable increase in fatigue, and the time lost in giving the patient this combined treatment, and the great quantity of material this method demands. Instead of from five to ten days of hospitalization for an application of radium, there is necessary one and one-half months of daily irradiation with x-rays, in order to obtain the absorption of a similar quantity of penetrating rays to that emitted by the radium. Nor can this always be accomplished without certain local and general reactions which may be very painful, sometimes even dangerous, or without the risk of certain permanent sequelæ.

It may be possible to draw some conclusions from the analysis of the recurrences in cases in Group I after intracavitary radium therapy; against 59 patients cured, there are here 17, 22 per cent. We have to discard three cases of extrapelvic recurrence. In these patients, there had existed for a long time, previous to the treatment, foci of disease, so that neither a combined radium therapy nor a hysterectomy could have changed the fatal termination.

There remain 14 intrapelvic recurrences. In only four of these was the extension uterine, probably because of non-sterilization of the primary lesion. Are these failures due to the type of cancer which belongs to the relatively insensitive tumors? Apparently they are not, for the microscopic examination showed the ordinary varieties of epitheliomas of the cervix.

In explaining the local recurrences, one is tempted to consider them as examples, confirming the fact which has been proven by experiment, that, for a certain kind of cell, no lethal dose exists; that lesions in similar tissues, exposed to the same conditions of homogeneous irradiation, do not always show similar results. Only this is definite, that there exists no certainty either as to the probability of survival of tissues or a certitude of their destruction by any determined irradiation. With the dose applied in intracavitary curietherapy to an epithelioma limited to the cervix, the probability that some cancerous cells escape death seems to be about 5 per cent. It is evident that this probability would diminish if the size of the dose were increased.

Concerning the parametral recurrences, most of them are the consequences of the unequal distribution of the irradiation by the intracavitary curietherapy technic; the intensity which is generally sufficient to kill the cells of cervical cancer, irradiated at a short distance and by cross-fire, is absolutely incapable of sterilizing the distant glandular invasion.

Under these conditions, combined radium therapy (local or transpelvic), should be used, even in cases in Group I, until the statistics have proven that the increase of cures does not compensate for the inconvenience of this method, which is not very probable.

CONCLUSIONS

1. The efficacy of local radium therapy alone is proved by the fact that the cure can be obtained by this method in 74 per cent of the cases of cervico-uterine cancer in the first degree.

2. On the other hand, this technic is frequently not sufficient in Group II cases, and almost completely ineffectual in cases in Group III.

3. The study of the recurrences justifies the hope that a greater proportion of cures in Group I will be obtained by treating these cases systematically with a combination of intracavitary and transpelvic irradiation.

FURTHER STUDIES ON THE PROBLEM OF MITOGENETIC RADIATION[1]

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ALTHOUGH more than 600 papers on the problem of mitogenetic radiation have been published, no uniform conclusions have been reached, even in regard to the fundamental question of the existence of this type of radiation. We (1) believed that, since there were so many contradictory reports, it would be desirable to investigate the problem by direct collaboration. This is a preliminary report of our researches.

Detector Arrangement.—The Geiger-Müller counter tubes, which we have used in our Cleveland laboratory for several years, are similar to those used in Gurwitsch's laboratory in Leningrad. However, while the presence of mitogenetic radiation was demonstrated in Gurwitsch's laboratory (2) with this type of apparatus, we were unsuccessful in obtaining positive results beyond the experimental error, though many different possible sources of radiation were used (3). Consequently, our first task in this collaboration was to construct counter tubes of the type used in Leningrad out of materials available in this country, and then to test them with a source of radiation which also had been used in Leningrad and which is easily reproducible.

The construction of the counter tube which we used has been described previously and (2) is shown diagrammatically in Figure 1. The cathode tube, *C*, has an inside diameter of 0.5 cm. and is 4 cm. long. In some of the tubes we used clean copper as the photo-electric surface, in others copper iodine; the preparation of these latter surfaces was described recently (2). The counter tube, *C*, is enclosed in a quartz test tube, *Q*, which is sealed with apiezon wax to the glass vessel, *G*. The counter is filled with hydrogen under a pressure of 15 mm.; in some experiments the pressure was increased to 150 mm.

In our first experiments, we connected the Geiger counter tubes to a circuit with a high tension rectifier system which fur-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

TABLE I.—ACTIVITY OF PAPERS

No. Experiments	Dark Rate		With Paper Tube		Dark Rate	With Paper Tube	Difference	
	Counts	Minutes	Counts	Minutes	Counts/1 min.	Counts/1 min.	Absolute	Percentage
A. Experiments with papersheets, which had been stored in the laboratory for a long time								
2	120	3.2	120	1.9	37.5 ± 3.4	63.2 ± 5.8	25.7 ± 6.7	68
3/4	300	15.8	300	8.9	19.0 ± 1.1	33.5 ± 1.95	14.5 ± 2.0	76
23	300	24.4	300	16.7	12.3 ± 0.72	18.0 ± 1.00	5.7 ± 1.23	46
B. Comparison of old sheets and new paper								
9/10								
old	630	29.0	630	22.5	21.7 ± 0.87	28.0 ± 1.1	6.3 ± 1.41	29
new	630	29.0	630	27.7	21.7 ± 0.87	22.7 ± 0.91	1.0 ± 1.26	5
29/36								
old	200	26.1	200	15.5	7.7 ± 0.54	12.9 ± 0.91	5.2 ± 1.06	68
new	500	45.7	500	44.2	10.9 ± 0.49	11.3 ± 0.51	0.4 ± 0.71	4
C. "New" papersheets several days later								
30/f	400	41.0	400	32.4	9.8 ± 0.49	12.4 ± 0.62	2.6 ± 0.79	26
31/f	600	64.5	600	58.0	9.3 ± 0.38	10.3 ± 0.42	1.0 ± 0.57	11

nished a potential of about 1,000 volts and a counting arrangement with a two-stage amplifier and a Cenco counter; we had used this circuit for several years in our laboratory. However, in order to avoid all possible disturbances from fluctuations in the line, we changed the circuit and operated the counter with dry cell batteries and observed the discharge with a string electrometer. This circuit is also shown in Figure 1.

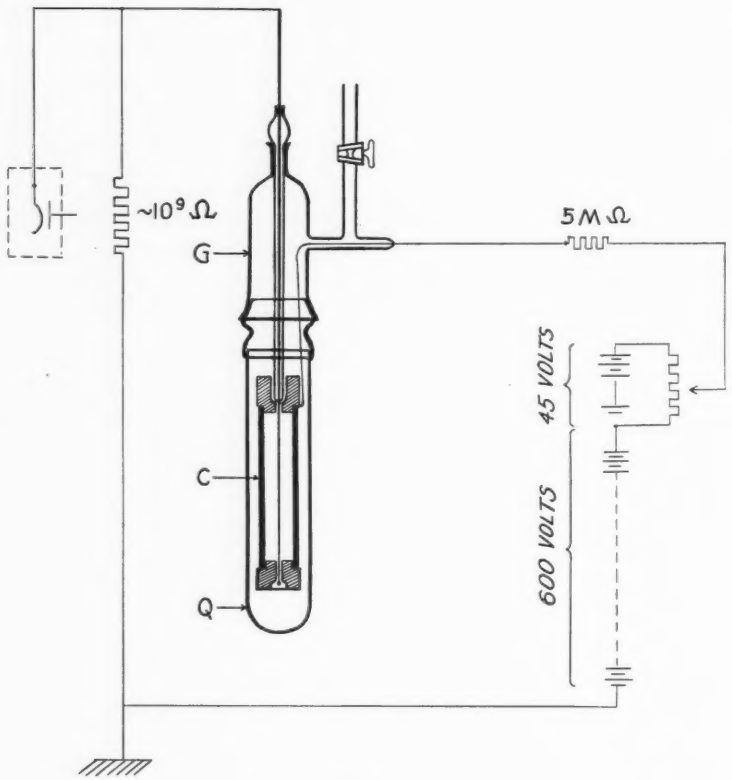

Fig. 1.

This change was necessary because the electrical impulses of the Leningrad counter tubes were very much weaker when used with the amplifier circuit than in our counter tubes; consequently the recording device did not respond to the Leningrad tubes until the voltage was increased considerably beyond the proper working voltage required for the tube. If the amplification factor of the recording device was increased, outside electrical disturbances appeared which prevented satisfactory readings. Therefore, the amplifier was first replaced by a string electrometer and later by a "magic eye." The counters worked satisfactorily with this circuit only at pressures of 150 mm., which was about ten times that used in the earlier work in Leningrad.

A number of experiments were made with this set-up, one of which showed a definite indication of a positive effect (Table IV, Counter 1). However, with the specific radiation source used in our experiments, a definite increase in the counting rate usually could not be obtained with the cell working at pressures as high as 150

mm. In attempting to work with the counter at pressures of only 15 mm., it was necessary to increase the sensitivity of the electrometer to such a degree that numerous disturbances interfered with the readings; therefore the rectifier was replaced by dry cell batteries.

Radiation Sources.—Earlier experiments carried out in Leningrad have shown that the oxidation reaction between $K_2 Cr_2 O_7$ and $Fe SO_4$ is a source of radiation which is easily reproducible and which also serves as a characteristic test for the sensitivity of counter tubes to mitogenetic radiation. The apparatus which we used for this reaction is shown in Figure 2. The reaction chamber was entirely closed to eliminate any effects from outside influences, such as vapors. Two long tubings lead from the reaction chamber into two large containers

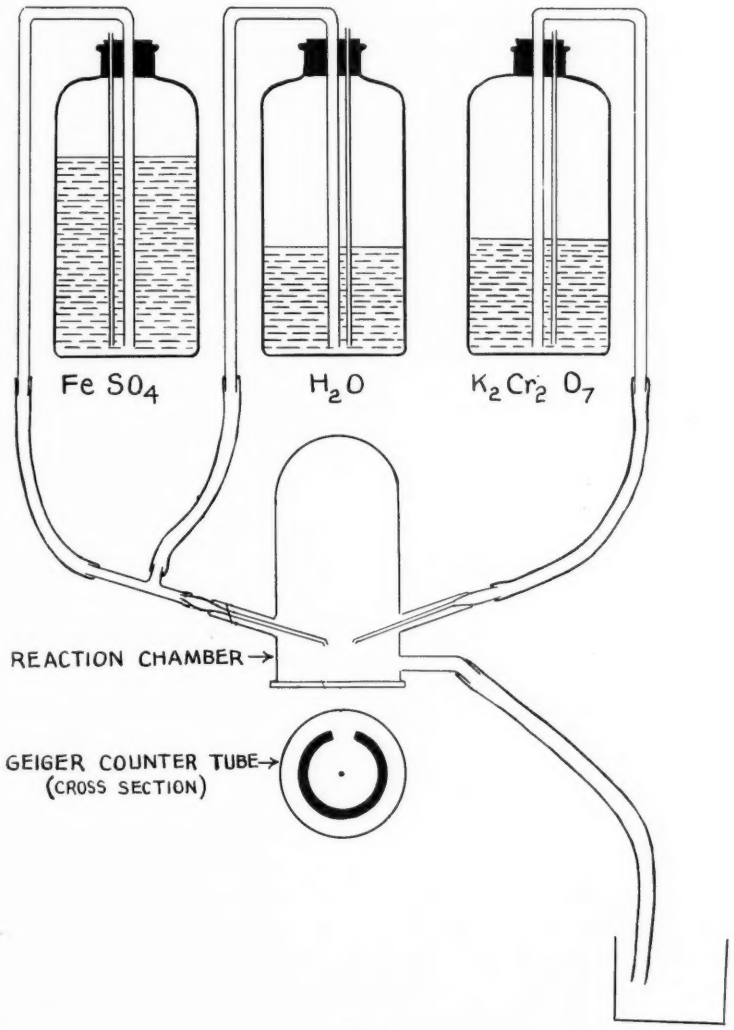

Fig. 2.

which hold the chemical solutions. After the mixing, the solution drains from the reaction chamber into a vessel standing under the table. The stand, contents of the reaction vessel, and bottles were

TABLE II.—EXAMPLE OF A SINGLE EXPERIMENT

(Time in minutes for 10 counts)

With reaction	Control	Controls made with
1.2	3.3	Cr
2.2	2.2	Fe
1.2	2.0	Fe
2.0	2.2	Cr
1.8	3.0	Cr
1.5	3.0	Fe
2.1	2.8	Fe
1.9	1.8	Cr
2.4	2.0	Cr
2.1	3.2	Fe
Total 18.4	25.5	
Counts Min. 5.4	3.9	Difference = 1.5 = 39%

grounded by copper wire in order to avoid electrostatic charges. A third bottle filled with water was used to replace the reaction fluids for control experiments.

The reacting solutions were one-tenth normal. The rate of flow of the $K_2 Cr_2 O_7$ solution was regulated with a clamp to two drops per second and that of the $Fe SO_4$ solution to three drops per second (following the suggestion of A. Pototzky). The proportions were carefully controlled and kept constant. Control counts were made (Tables II and V) by stopping the flow of one of the reaction components or by replacing the reacting liquids with water.

In the next chapter we will explain why it was not advisable to make control counts in our laboratory by removing the reaction vessel from the counter window or by inserting a glass plate between the radiation source and counter. We found that all movable articles in this laboratory increased the counting rate when brought near the counter. Control experiments of this type, therefore, are not reliable unless special experiments are made to test the possible radio-activity of all movable articles. We have been unable to carry out a complete study of this phase.

Influence of Radio-active Materials.—The presence of a radium emanation apparatus containing almost one gram of radium in the basement of our laboratory building naturally brought up the question of whether or not contamination of the rooms and equipment with radio-active deposits was responsible for the failure, or at least for the numerous difficulties, encountered in our mitogenetic experiments. It is well known that the counter tubes are extremely sensitive to radio-active materials.

Since a number of counter tubes made exactly alike in the simple manner previously described (2) may show considerable differences in their dark-count rates, it is often difficult to determine definitely to what degree an additional ionization may influence the counting rates of single experiments. However, observations made during some of our first experiments made us suspect that this might occur and interfere considerably with the readings. The counter tube was enclosed in a tube of black paper in order to study the sensitivity of the counter for visible light. Contrary to our expectations, the counter tube then produced a larger number of clicks. The effect was increased when the experiment was repeated in a completely dark room.

Since the dark rate for these counter tubes did not show changes in similar experiments in Leningrad, this peculiar behavior must have been due to a weak radio-activity of the paper which had been stored in our laboratories for a long time. A systematic check of fresh papers proved this assumption to be correct. Data in Table I show that the old paper had a definite effect upon the counter, whereas fresh ones did not show any action beyond the limit of error; it is probable that even the new paper assumed a weak activity after it had been kept in the laboratory for a few days. These disturbances clearly demonstrate the difficulties of a systematic investigation of the mitogenetic radiation in a building housing a radium emanation plant. Unfortunately, we were not able to

transfer our whole equipment to a place where no radio-active influences could be detected. Traces of radio-activity could be found in all of the widely scattered buildings of the Cleveland Clinic Foundation. Although these traces are far below the point of danger to the personnel, they definitely interfered with our mitogenetic work. However, it seemed to us that experiments with the chemical reaction, as described, might permit us to distinguish between the expected effects of ultra-violet radiation emitted during the reaction and the effects due to a weak radio-activity of the reacting liquids.

Experiments.—The experiments in Leningrad had proved that not all counter tubes will show a response to chemical reactions, even though they may be constructed in exactly the same way as those which do. Therefore, we had to determine how many good tubes might be found in a lot built according to specifications and also whether tubes found to be satisfactory in the first experiments remained constant in subsequent tests.

Thirty-three counter tubes were built here and each was subjected to a short test. Table II shows the data obtained in one experiment. The time for ten counts was measured while the chemical reaction took place in front of the counter window: then the reaction was stopped and the count repeated. Readings were thus taken with alternating settings until the total of the dark counts reached about one hundred. It was necessary to confine a single experiment to this number of counts in order to limit the time, although the result is subject to a high degree of statistical uncer-

TABLE III.—COUNTER TESTS

Counter No.	Test No.	Control		Reaction		Counts/ Minutes		Difference		Pressure
		Counts	Minutes	Counts	Minutes	Control	Reaction	Absolute	Percentage	
1	5	220	14.0	220	12.2	15.7	18.0	2.3	15	150 mm.
2	13	100	6.6	100	8.4	15.2	11.9	−3.3	−22	
3	24a	100	9.4	100	8.8	10.6	11.4	0.8	8	
Total		420	30.0	420	29.4	14.0	19.3	0.3	2	
4	44	160	43.7	160	35.0	3.7	4.6	0.9	24	15 mm.
4a	45	120	53.5	120	46.4	2.2	2.6	0.4	18	
5	48	100	22.3	100	20.5	4.5	4.9	0.4	9	
6	54	130	54.2	130	46.4	2.4	2.8	0.4	17	
7	56	100	22.5	100	14.7	4.4±0.4	6.8±0.7	2.4±0.8	52	
8	59/60	120	34.3	120	24.9	3.5±0.3	4.8±0.4	1.3±0.5	37	
9	75	120	22.6	120	24.5	5.3	4.9	−0.4	− 9	
10	76	170	29.3	170	24.4	5.8	7.0	1.2	17	
11	80	100	19.7	100	19.7	5.1	5.1	0.0	0	
12	81	120	32.9	120	27.2	3.7	4.3	0.6	15	
13	82	110	19.4	110	19.9	5.2	5.0	−0.1	− 3	
14	83	100	43.1	100	39.4	2.3	2.5	0.2	9	
15	85	200	16.9	200	16.0	12.0	13.0	0.7	6	
16	86	120	46.1	120	29.6	2.6±0.2	4.1±0.4	1.5±0.4	56	
17	87	60	10.7	60	6.5	10.7	9.3	−1.4	−16	
19	88	80	40.6	80	35.8	2.0	2.2	0.3	14	
20	89	110	28.6	100	29.2	3.5	3.4	−0.1	− 2	
21	90	100	21.8	100	23.4	4.6	4.3	−0.3	− 7	
22	91	100	16.0	100	17.4	6.3	5.8	−0.5	− 9	
23	92	100	18.9	100	17.6	5.3	5.7	0.4	7	
24	94	100	14.8	100	14.4	6.7	6.9	0.2	3	
25a	95a	70	22.4	70	24.2	3.1	2.9	−0.2	− 8	
25b	95b	110	54.0	110	44.2	2.0	2.5	0.5	18	
26	96	100	27.8	100	29.6	3.6	3.4	0.2	7	
27	97	120	35.8	120	25.2	3.7±0.3	4.8±0.4	1.1±0.5	31	
28	98	30	10.2	30	8.9	3.0	3.4	0.4	12	
29	106	100	53.5	100	48.8	1.9	2.1	0.2	10	
30	107	90	34.6	90	23.9	2.6±0.3	3.8±0.4	1.2±0.5	31	
31	108	100	47.5	100	32.2	2.1±0.2	3.1±0.3	1.0±0.4	48	
32	109	100	29.8	100	31.6	3.4	3.2	−0.2	− 6	
Total		3230	923.9	3230	801.0	3.50±0.06	4.03±0.07	0.53±0.094	15.1	

tainty if the effects obtained are rather small.

Table III gives the results obtained with the 33 experiments and shows a total count which exceeds from five to six times the limit of error. Twenty-four of the single tests are on the positive side and nine on the negative. Six of the positive results are over the limit of error twice and two of them three times. All the negative results are smaller than the limit of error except No. 13, which is smaller than twice the error. Judging from the results in this table, we must assume that the radiation

TABLE IV.—REPEATED EXPERIMENTS WITH SINGLE COUNTERS

Counter No.	Experiment No.	Control		Reaction		Counts/Minutes		Difference	
		Counts	Minutes	Counts	Minutes	Control	Reaction	Absolute	Percentage
A. "Sensitive" Counters									
		Reaction $FeSO_4 + K_2Cr_2O_7$							
1	5	120	8.0	120	6.5	14.9	18.5	3.6	24
		100	6.0	120	5.7	16.8	17.6	0.8	5
	6	120	6.2	120	5.0	19.9	24.1	4.2	21
		120	6.5	120	5.7	18.5	21.1	2.6	14
	7	120	5.1	120	5.4	23.5	22.2	−1.3	− 6
	8	100	5.0	120	4.5	20.2	22.2	2.0	10
		100	6.8	100	6.3	14.8	19.1	4.3	29
		100	6.0	100	5.4	16.7	18.5	1.8	11
		100	5.1	100	3.9	19.8	26.0	6.2	31
		100	5.2	120	5.5	23.3	22.0	−1.3	− 6
Total		1100	59.6	1100	52.17	18.4 ± 0.63	20.9 ± 0.56	2.5 ± 0.84	14
5	48	100	22.3	100	20.5	4.5	4.9	0.4	9
	49	140	24.7	140	17.9	7.8	5.7	2.1	37
	50	60	20.8	60	13.2	2.9	4.5	1.6	55
	51	230	65.7	230	57.3	3.5	4.0	0.5	14
	52	100	24.9	100	23.5	4.0	4.3	0.3	8
	53	100	20.9	100	20.6	4.8	4.9	0.1	2
Total		730	189.3	730	153.0	3.86 ± 0.14	4.77 ± 0.16	0.91 ± 0.21	23.5
7	56	100	22.5	100	14.7	4.4	6.8	2.4	53
	58	110	20.5	110	17.9	5.4	6.2	0.8	15
Total		210	43.0	210	32.6	4.88 ± 0.34	6.44 ± 0.40	1.56 ± 0.52	32
8	59/60	120	34.3	120	24.9	3.5	4.8	1.3	37
	63	100	23.9	100	18.2	4.2	5.5	1.3	31
	69	100	25.3	100	18.2	4.0	5.5	1.5	39
	71a	100	20.2	100	19.5	5.0	5.1	0.1	2
	72a	90	18.7	90	16.8	4.8	5.3	0.5	10
	74	100	23.0	100	21.9	4.4	4.8	0.2	5
	73	100	20.6	100	22.6	4.9	4.4	−0.5	−10
Total		710	166.0	710	142.1	4.28 ± 0.16	5.00 ± 0.19	0.72 ± 0.25	17
10	76	170	29.3	170	24.4	5.8	7.0	1.2	17
	77	70	31.5	70	23.3	2.2	3.0	0.8	26
	71	100	49.9	100	47.1	2.0	2.1	0.1	6
Total		340	110.7	340	94.8	3.07 ± 0.15	3.59 ± 0.17	0.52 ± 0.23	17
28	98	30	10.2	30	8.0	3.0	3.4	0.4	12
	99	100	33.9	100	24.4	3.0	4.1	1.1	39
	105	120	41.4	120	40.2	2.9	3.0	0.1	3
Total		250	85.5	250	73.5	2.93 ± 0.19	3.40 ± 0.21	0.47 ± 0.28	16
						Experiments with Blood			
16	100	124	40.0	124	33.6	3.1	3.7	0.6	19
	101	55	27.0	55	21.3	2.1	2.6	0.5	26
25b	102	63	28.0	63	20.7	2.2	3.0	0.8	35
27	103	150	21.3	150	17.7	7.0	8.5	1.5	21
	104	124	28.0	124	22.1	4.4	5.6	1.2	26
Total		516	144.3	516	115.4	3.58 ± 0.16	4.49 ± 0.20	0.91 ± 0.25	25

source investigated had a small but definite action upon our counter.

The average effect, as shown in Table III, is only 15 per cent. It is to be expected, however, that if some of the counters could be tested again, they would show a higher average result, since the single counters would probably have a different sensitivity toward the reaction. Several of the counters which we thought showed a higher sensitivity with the reaction were, therefore, used in the larger number of tests. The results obtained are shown in Part A of Table IV.

In order to find out whether or not a negative result exceeding the limit of error could be obtained in our control experiments, we also made a large series of experiments with counters which seemed to show high negative results. The results of these experiments are given in Part B of Table IV.

The average effects obtained are seen to be between 14 per cent and 23 per cent, as shown in Part A in Table IV. Five of the six results exceed twice the error and three exceed three times the error, while in Part B none of the results exceeds twice the error.

We also started to investigate blood as a radiation source with some of our good counters. The small series of five blood experiments shows a positive total which is greater than three times the average error.

In order to make a further study of the effect, we varied the methods for the determination of the dark rate. As men-

TABLE IV.—REPEATED EXPERIMENTS WITH SINGLE COUNTERS (*Continued*)

Counter No.	Experiment No.	Control		Reaction		Counts/Minutes		Difference	
		Counts	Minutes	Counts	Minutes	Control	Reaction	Absolute	Percentage
B. "Insensitive" Counters Reaction $FeSO_4 + K_2Cr_2O_7$									
2	13	100	6.6	100	8.4	15.2	11.9	−3.3	−22
	14	100	8.2	100	8.6	12.2	11.6	−0.6	− 5
	15	100	4.9	100	4.5	20.4	22.2	1.8	9
	16	100	5.3	100	4.5	18.9	22.2	3.3	17
	17	100	9.7	100	9.2	10.3	10.9	0.6	6
	18	100	6.7	100	6.5	14.9	15.4	0.6	3
	19	100	8.2	100	7.1	12.2	14.1	1.9	16
	20	120	9.7	120	9.5	12.4	9.5	0.2	2
	21	120	7.8	120	9.4	15.4	12.8	−2.6	−17
	22	120	8.7	120	10.0	13.8	12.0	−1.8	−13
Total		1060	75.8	1060	77.6	14.0 ± 0.38	13.6 ± 0.42	− 0.4 ± 0.57	− 3
3	24a	100	9.4	100	8.8	10.6	11.4	0.8	8
	24b	140	15.2	140	15.6	9.2	9.0	−0.2	− 2
		100	12.2	100	13.4	11.5	10.5	−1.0	− 9
	25	120	12.0	120	12.2	10.0	9.8	−0.2	− 2
		120	11.3	120	10.0	10.7	12.0	1.3	12
		140	12.6	140	11.5	11.1	12.2	1.1	12
	26	100	8.0	100	9.6	12.6	10.4	−2.2	−17
		100	10.3	100	8.0	9.7	12.6	2.9	30
		120	11.6	120	12.4	8.5	8.1	−0.4	− 5
Total		1030	102.7	1030	101.4	10.0 ± 0.31	10.2 ± 0.32	0.2 ± 0.45	2
6	54	130	54.2	130	46.4	2.4	2.8	0.4	17
	55	100	25.8	100	25.1	3.9	4.0	0.1	3
Total		230	80.0	230	71.5	2.88 ± 0.19	3.22 ± 0.21	0.34 ± 0.28	12
14	83	100	43.1	100	39.4	2.3	2.5	0.2	9
	84	80	17.3	80	22.4	4.6	3.6	−1.1	−23
Total		180	60.4	180	61.8	2.98 ± 0.30	2.91 ± 0.29	−0.07 ± 0.42	− 2.4
23	92	140	39.8	140	37.8	3.5	3.7	0.2	5
	93	100	18.9	100	17.6	5.3	5.7	0.4	7
Total		240	59.2	240	55.4	4.06 ± 0.23	4.33 ± 0.25	0.27 ± 0.34	7

tioned previously, the dark rate measurements were made while the reaction chamber was alternately filled with only one of the reaction components or with pure water. These controls should all show the same effect, if the positive observed effects are due exclusively to ultra-violet radiation emitted from the reaction. If, however, the weak radio-activity of the liquids is responsible for part of the effects shown in Tables III and IV, it is to be expected that experiments made with different types of controls would produce different results. Since the amount of liquid in the reaction chamber was the same during the counts with the reaction and during the control, a radio-activity of the liquids could have caused the effects observed only if either the iron or the chromium solution had been more active than the other liquids. Such an effect should have caused a difference between the experiments controlled with the Fe SO_4 solution and those controlled with the K_2 Cr_2 O_7 solution. Since

TABLE V.—SEPARATE RESULTS FOR DIFFERENT CONTROLS

No.	Control ($K_2Cr_2O_7$)	Reaction Minutes	No. Counts	Control ($FeSO_4$)	Reaction Minutes	No. Counts	Control (water) Minutes	Reaction Minutes	No. Counts
A. Experiments with a total effect greater than 20 per cent									
27	11.2	9.7	40	11.6	7.4	40	10.2	8.1	40
28	17.5	11.6	50	16.4	12.8	50	..	..	..
59/60	20.4	13.0	60	13.9	11.9	60	23.9	18.2	100
69	12.2	9.2	50	13.1	9.0	50	..	..	..
86	21.1	11.1	60	22.7	17.2	80	2.6	1.4	10
77	16.1	11.3	30	12.9	10.6	30	2.5	1.4	10
99	16.4	12.8	50	17.5	11.6	50	..	..	..
Total	114.9	79.0	340	108.0	80.5	360	38.9	29.1	160
Counts	2.96	4.31		3.32	4.48		4.12	5.50	
Minutes	±0.16	±0.23		±0.18	±0.24		±0.33	±0.44	
Difference	1.35±0.26 = 46%			1.16±0.30 = 35%			1.38±0.55 = 34%		
B. Experiments with a total effect less than +20 per cent									
71a	10.2	11.2	50	10.0	8.3	50	..	..	..
72a	6.7	6.4	30	12.2	10.7	60	..	..	..
73	11.0	11.8	50	9.6	10.8	50	..	..	..
74	9.9	11.4	50	13.0	10.5	50	..	..	..
75	10.3	10.3	60	10.7	12.6	50	1.8	1.8	10
76	12.3	10.6	80	13.2	9.7	70	3.9	4.1	20
79	7.9	7.8	20	7.8	7.4	20	34.3	32.0	60
80	6.6	9.3	40	9.0	6.5	40	4.0	3.8	20
81	14.8	12.6	50	13.7	9.9	50	4.3	4.7	20
82	4.9	5.8	30	6.5	7.6	40	8.0	6.5	40
83	19.9	19.2	50	23.2	20.3	50	..	..	..
84	9.8	12.5	40	7.4	9.8	40	..	..	..
88	20.1	17.1	40	20.5	18.7	40	..	..	..
89	16.3	14.3	50	12.4	14.8	50	..	..	..
90	11.4	13.6	50	10.3	9.8	50	..	..	..
91	7.7	9.9	50	8.4	6.5	50	..	..	..
92	8.6	8.9	50	10.4	8.7	50	..	..	..
93	19.6	20.2	70	20.2	17.6	70	..	..	..
94	8.7	7.2	50	6.3	7.2	50	..	..	..
95a	15.1	15.8	40	7.4	8.4	30	..	..	..
95b	33.3	21.9	60	20.7	23.0	50	..	..	..
96	14.1	12.8	50	15.5	15.0	50	..	..	..
98	8.7	5.5	20	1.5	3.4	10	..	..	..
105	19.7	20.4	60	21.8	19.8	60	..	..	..
106	25.2	24.1	50	28.3	24.1	50	..	..	..
109	16.3	17.0	50	13.5	14.6	50	..	..	..
Total	348.9	336.6	1240	333.2	315.2	1230	66.3	62.9	170
Counts	3.55	3.68		3.70	3.91		2.57	2.70	
Minutes	±0.10	±0.11		±0.11	±0.11		±0.20	±0.21	
Difference	0.13±0.15 = +4%			0.21±0.16 = 6%			0.13±0.29 = 6%		

the number of counts of any one kind of control in a single experiment is too small to permit a definite conclusion, it must be studied by summation over a series of our tests. Table V-*A* shows the average effects for the single controls of all tests which gave a total result greater than 20 per cent, or, in other words, the results of all tests which show a difference greater than two times the statistical error of 100 dark counts. These experiments should show a positive average result, no matter how the control counts were made.

The same calculations were made for all experiments with a total result of less than 20 per cent. The results are shown in Table V-*B*. The average effect of all partial results in this table should be definitely smaller than the results shown in Table V-*A*. The tables show the results expected. In Table V-*A*, the chromium controls as well as the iron controls showed positive results, namely, 46 per cent, or about five times the mean error for the chromium solution, and 35 per cent, or about four times the mean error for the iron solution. A calculation of the data below 20 per cent in no instance produced an effect which reaches twice the error. So far, the controls made with water agree with those made with iron and chromium. We must therefore conclude that the results of our counter-tube tests are not due to radio-activity of one of the liquids used in the reaction apparatus.

A survey of all the experiments made during the last year, both published and unpublished, has convinced us of the futility of carrying out successfully any mitogenetic work in a building which is infected with radio-active decay products. We have therefore decided to continue our efforts in buildings which are entirely free from any of the effects of such radio-active products.

We wish to express to Mr. I. E. Beasley our appreciation for his helpful assistance in many of these experiments.

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ROENTGEN EVIDENCE OF PULMONARY TUBERCULOSIS IN SUPPOSEDLY HEALTHY INDIVIDUALS[1]

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KOCH, after discovering the tubercle bacillus, remarked that while the attempt had been made again and again to prove, on the evidence of collected clinical observation, that phthisis is contagious, the theory had met with no acceptance by the scientific world.

After he proved that the causative agent is the tubercle bacillus, he said that it was probable that there was no prospect that we could find a therapeutic means of dealing with the parasite within the body, and it would seem that the time had come to adopt prophylactic measures against tuberculosis. This was in 1884.

It seems that now, after 54 years, we have come to realize fully that the primary factor in prophylaxis consists in case-finding, and, when found, locating the source from which the infection was derived. If the second step is not taken, little good can accrue to the general public as a result of finding the new case, for while he or she may not be in an infective stage, the one from whom he derived the infection certainly is and, furthermore, will continue to infect others.

In various parts of the country surveys are being made of large groups of individuals, most of whom are presumably in good health. The results of these surveys show a surprising incidence of unrecognized tuberculosis in those who little suspect they are affected.

The economic problem in carrying out these studies is a very serious one to meet. To obtain co-operation of individuals who believe themselves well is not always a simple matter. If every person should be compelled to submit to a dermal test plus a roentgenographic examination, if reacting positively, the cost and labor involved would be almost beyond calculation. That such a method would uncover the disease in millions of our population is without doubt true, in view of the statistics available. It would not disclose all of the inhabitants suffering from the disease. To be of greatest value, repetition of the test is necessary. Dow and Lloyd (1), describing the study of 500 children, found that of 225 giving a negative tuberculin test 35 per cent had positive findings by x-ray examination. Twenty-two of 51 children that showed calcification of tracheobronchial nodes reacted negatively to the tuberculin test.

It is now believed by some that there is little relation between Ghon tubercles or calcified nodes and the Mantoux test. It would appear desirable, however, best to begin such surveys with the dermal test, not only because of its value *per se* but on account of the low cost of the material used and the facility of applying it to large groups.

Myers, Diehl, Lees, and Levine (2), working in collaboration, describe the results of their examinations of student nurses, by the Mantoux test, from the time of their entrance to graduation. In one school these tests, as applied to the 1929 and 1930 classes, showed 23.08 per cent positive reactors on admission, and 91.23 per cent positive at graduation. This was in a hospital in which there was a tuberculosis division in which each nurse was compelled to spend three months of her training. In another training school, without a tuberculosis division, which admitted an occasional tuberculous patient, the incidence of positive reactors was not as great. The total incidence of 1929 and 1930 classes on entering was 30.51 per cent and on graduating, 37.21 per cent. In the same school, however, the 1931 and 1932 classes showed 20.34

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

per cent on entering and 54.35 per cent on graduating.

It is very obvious from these figures that the more contact had with tuberculous patients the greater the increase in percentage of reactors among the nurses, and that some such technic in the handling of tuberculous patients in an infective stage, as is used in handling patients with other infectious diseases, would reduce the incidence among the nurses.

The x-ray, unfortunately, helps only in determining the site of the first infectious type of lesion in a small percentage of the cases. There are many reasons for this, from obscuration by other structures, as heart and great vessels, to location of the lesion in some other part of the body. The re-infection type of lesion, however, is readily demonstrated by x-ray examination at an early stage in its development and when the most helpful treatment may be applied, with great saving in money and time lost from normal activities.

The work reported in this paper is not the result of a planned survey, as will be explained later. Relatively few of the individuals reported herein received the dermal test. We were prompted to this review by the fact that we were more or less incidentally finding tuberculosis with great frequency in presumably well individuals with no known clinical symptoms, who were seeking employment or admission to a training school and who, prior to x-ray examinations, had passed satisfactory physical examinations.

The tendency of employers, hospitals, schools for nursing, and colleges to require roentgenograms demonstrating healthy lungs before the acceptance of workers or students is increasing. In helping to carry out these requirements we have, during the past few years, had the privilege of examining the chests of three groups of individuals who planned to enter a new type of work. The individuals of each of these groups had expressed no knowledge of any current illness and had passed a physical examination satisfactorily before being studied roentgenographically. A review of the roentgen findings in these individuals revealed unsuspected active tuberculous lesions of the lungs so frequently that we believe the summation worth reporting at this time. No attempt will be made to correlate these findings with the general incidence of tuberculosis which varies as to locality, climate, and other factors.

Our studies include a rather large group of young women examined when about to enter training schools in two hospitals of Newark, New Jersey, and one in East Orange, New Jersey. Subsequent examinations were made of those becoming ill during the course of training. Other studies were made of all prospective employees of the Home Office of the Prudential Life Insurance Company, situated in Newark, New Jersey, and employees of

TABLE I.—CHEST X-RAY EXAMINATIONS

(Applicants for Employment, September, 1934, through April, 1938)

	Minimal		Mod. Adv.		Far Adv.		Total Number	Total Percentage
	#	%	#	%	#	%		
Total Number Examined							4,662	100
Adult Tuberculosis							41	0.88
Probably active	17	0.37	4	0.09	2	0.04	23	0.49
Probably cured	13	0.28	5	0.11	0		18	0.39
	30	0.65	9	0.20	2	0.04		
Other Lung Abnormalities							17	0.37
Total Lungs Abnormal							58	1.24

the Western Electric Company, who were engaged in, or about to be assigned to, the work known as sandblasting.

We recognize the difficulty in describing the healthy chest because of wide normal variations. We like the description given by Wessler and Jaches which is too long to be quoted here. In our work we prefer to consider the ideal healthy rather than the "normal" chest about as follows:

(1) A smooth diaphragm with absence of indications of thickened pleura in the costophrenic angles.

(2) Absence of thickened pleura of the apices; the so-called apical cap.

(3) Vascular markings of normal density and distribution.

(4) Absence of cloudiness in any portion of the parenchyma.

(5) Lack of mottling from nodule formation.

(6) Absence of calcific deposits.

(7) Absence of increased hilus densities.

(8) Absence of healed lesions of any type.

(9) Heart and aortic shadows within normal limits.

One has to decide from experience and the possible hazards of the prospective employment how much attention should be paid to the finding of abnormal shadows in a given individual. For instance, in the absence of any other finding, either roentgen or clinical, should the presence of a single Ghon tubercle or calcification of the peribronchial or paratracheal nodes prevent one's employment in a clerical or secretarial position? At the Prudential Home Office these findings alone are no longer considered sufficient to preclude the employment. In our hospitals they do not prevent admission to the training schools. On the other hand, in evaluating the chests of individuals who run the risk of irritation of the lungs from the inhalation of fine dust particles, as in sandblasting, we have considered the presence of any

TABLE II.—CHEST X-RAY EXAMINATIONS

(Home Office Employees, Including Applicants)

	Number	Percentage
Total Examined (Sept. 1, 1933 to April 1, 1938)	9,301	100
Lungs Normal	8,285	89.1
Lungs Normal, with Calcification	762	8.2
Lungs Abnormal	258	2.8
Applicants for Employment	58	0.6
Home Office Employees	200	2.2
Adult Tuberculosis	196	2.1
Applicants for Employment	41	0.4
Home Office Employees	155	1.7
Other Chest Abnormalities	62	0.7
Applicants for Employment	17	0.2
Home Office Employees	45	0.5

TABLE III.—CHEST X-RAY EXAMINATIONS

Home Office Employees, September, 1933, to May 1, 1938. Non-Tuberculous Chest Conditions

Age Group	Abscess	Tumor		Pneumonitis	Pleurisy with Effusion	Bronchiectasis	Spontaneous Pneumothorax	Miscellaneous
		Benign	Malig.					
Under 20				1			1	
20–24	1			7	3		5	2
25–29	1	1		6	3	3	3	
30–39				6	1		1	
40–49			1	1			1	3
50–59	1		4	2	2			3
60 and over								
Total 63	3	1	5	23	9	3	11	8

evidence of healed tuberculosis, even of the first infection type, warrants a recommendation that the individual be assigned to a less hazardous occupation.

Technic.—The technic employed is either a 200 ma. for $^1/_{10}$ of a second, or 300 ma. for $^1/_{20}$ of a second exposure in the upright posture, five or six foot distance, with the rays passing in a postero-anterior direction through the sagittal plane. The kilovoltage employed is judged according to the largest anteroposterior diameter of the thorax, and sufficient penetration is produced to visualize the lung markings well out into the peripheral portions of the lungs near the axillæ. Extreme contrasts obtained through the use of low voltages, high milliamperage, and prolonged development at higher than normal temperatures are no longer preferred by us, as it is extremely easy to overlook faint shadows indicating primary lesions with roentgenograms of that quality. The instantaneous Bucky diaphragm is used at four feet, to make supplementary examinations in certain instances, and the rotating anode tube is employed when included in the installation. It has been found that perfect screen film contact is a prime essential in rendering sharpness of detail.

In the year immediately preceding the installation of x-ray equipment at the Prudential Home Office, we examined, at our office, about one hundred of the Company's employees who had seen service for variable periods of time and had developed tuberculosis during employment. In several instances, employees who had been engaged in the service of the Company from five to ten years and who had been absent on account of sickness less than two weeks during that service, were found to have advanced tuberculous lesions in one or both lungs, with cavitation and sputum markedly positive. These individuals had passed satisfactory physical examinations before being employed but up to that time were not required to have roentgenograms made of their lungs. They were entitled to apply to the Infirmary at the Home Office for diagnosis and advice but not for medical treatment. The insidiousness of the onset of this disease and the danger to co-workers, as well as the community at large, when it goes unrecognized, is well demonstrated by these experiences.

The Company, after installing modern x-ray equipment and engaging competent technical personnel and supervision by a physicist, requested us to act as consultants in roentgen studies of the lungs. Although it had been the practice of this, as of other life insurance companies, to aid the employees developing tuberculosis while in their employ by free sanatorium treatment, the problem of caring for affected employees was then freshly attacked in three ways, which include, as described by Ylvisaker (3):

"1. *Pre-employment Examinations.*—Clinical examinations alone are not adequate, as experiences such as the following show:

"A boy, 18 years of age, applied for work on April 16, 1934; passed his clinical examination and when he became ill four months later an x-ray examination showed a far-advanced bilateral pulmonary tuberculosis with extensive cavity formation. His sputum was also markedly positive.

"Those who have had considerable experience in the diagnosis of lung conditions know how difficult it often is to detect early and even more advanced tuberculous lesions without the aid of the x-ray. The statement that early tuberculous lesions are seen, not heard, is very apt and is in agreement with our conclusion that any chest examination which is made for the purpose of eliminating tuberculosis is incomplete without an x-ray film.

"Since Sept. 1, 1934, pre-employment examinations have, therefore, included a single x-ray film of the chest, and during the period up to May 1, 1938, 4,662 applicants for employment have been so examined. Forty-one, a little less than 1 per cent, have shown definite evidence of pulmonary tuberculosis of the adult or re-infection type, with lesions varying from the minimal to the far advanced, and from the definitely active to the apparently cured. Seventeen other chest conditions were also found which required further investigation.

"2. *Periodic Examinations and Examinations Following Illness and Disability.*—Satisfactory as the results of these pre-employment examinations have been, they are not sufficient

Employees, who at the time of their pre-employment examination, are found free from tuberculosis may at any time develop an active lesion. In order to detect these incipient lesions, the Prudential encourages but does not require periodic examinations, urges all employees to consult with their own physician when they become ill and unable to work, and to report back to the Infirmary for a review of their condition before returning to work. Those who have shown any suggestive manifestations of tuberculosis are observed carefully while at work in accordance with any recommendations received from their attending physicians until we feel reasonably certain that there will be no later unfavorable developments.

"3. *Rehabilitation.*—The Prudential does not undertake to treat any of its employees because it feels that this is altogether the function of the attending physician. Its activities have, therefore, been limited to:

"(1) Co-operating with the attending physician in placing these employees in private sanatoria;

"(2) Assisting and encouraging these employees in remaining at these sanatoria until their lesions are healed, until they are no longer infective to others, and until they have been on sufficient exercise to make it safe for them to consider returning to part-time employment;

"(3) Assisting them to return to their former positions, at first on a part-time basis, with later gradual return to full-time employment;

"(4) Close observation after return to work, to make certain that they can continue without endangering their health, that they develop no recurrence, and that they remain free from infection to others.

"From Jan. 1, 1927, to Dec. 31, 1937, a period of 11 years, 157 cases of active tuberculosis have been found among Home Office employees, and most of them have been treated in sanatoria during their period of activity and infectivity. Twenty-three of these have died, a mortality of between 14 and 15 per cent; 22 are still at a sanatorium; seven are still at home; 18 have had recurrences, and 106 have been returned to duty. Of these 106, five have since been retired; 39 have resigned, and 62 are still on duty. Seven of these on duty are still being given pneumothorax by their attending physicians.

"The average sanatorium stay has been a little over a year and seven months and the average total disability one year and ten months.

"We cannot here enter into a more detailed discussion of the work which has been done and the results accomplished. A total of 9,301 employees, including applicants for employment, have been studied in the manner outlined, including x-ray examination, and the results have been analyzed.

"The work is being done as a supplement and aid to that of the attending physician and in co-operation with him, all of us united in the one endeavor—to relieve the individual, for whom we have some responsibility, of a part of the burden imposed on him by tuberculosis."

Our experience in uncovering lesions in nurses, before and after entering the training schools of three hospitals, is as follows:

In the past fifteen years, in the first hospital, only three nurses have died as a result of tuberculosis and one patient with an arrested lesion contracted a fatal pneumonia.

In the years between 1934 and 1938, 104 nurses were examined; of these, 15 had some slight evidence of the first infection type of tuberculosis in calcified hilus shadows or Ghon tubercles. We have not been able to trace the number of dermal test positives, but of the 15 showing calcified nodes, etc., only one has developed active lesions necessitating sanatorium treatment.

Case 1. An adopted daughter was examined by roentgenogram at the time of adoption and was said to have had a healed lesion of the childhood type. She was admitted to the training school and when the time came for her to affiliate with another hospital for special training, she was reexamined and found inactive. When she entered the second hospital another chest examination was negative. She became active during her stay at that institution and her lesion was discovered when she was about to return to our hospital. There was no fatigue or loss of weight and no consciousness of fever, but she was placed in a County tuberculosis sanatorium where repeated sputum tests were negative. The temperature was slightly above normal. Examination of the stomach contents was finally positive for tubercle bacilli. She was kept in the sanatorium for one year and is about to return to duty.

In the second hospital, in 1936, of 31 nurses examined, tuberculosis was found in two; in 1937, 70 nurses were examined and only one case was found; in 1938, 101 nurses were examined and two cases were found. Although the routine entrance roentgenogram is negative, it is possible that the nurse may contract tuberculosis and become infective to others.

TABLE IV.—PRUDENTIAL EMPLOYEES WITH SPONTANEOUS PNEUMOTHORAX IN OTHERWISE NORMAL INDIVIDUALS

Number affected	11
Ages at onset	
Youngest	19 years
Oldest	44 years
Weight	
Lowest	96 pounds
Highest	160 pounds
Previous x-rays available and negative	4
Side	
Right side	11
Left side	8

Other x-ray findings negative excepting one slight exudate in right base.

Clinical condition otherwise negative except one parent died of tuberculosis one year previously.

Follow-up x-rays negative as to tuberculosis in all cases.

Tuberculin test positive in four cases.

Case 2. When giving x-ray therapy one day, the roentgenologist heard from the technician that the nurse accompanying the patient to the department had a bad cough and fever. Her chest was x-rayed and an exceedingly active tuberculosis was found. The sputum was positive. She was treated in a sanatorium and finally recovered.

Of 44 nurses examined in the third hospital in one year, 14 showed positive Mantoux tests, seven showed calcifications either at the hila or in the form of Ghon tubercles, five showed increased local densities of the parenchyma, four showed adhesions to the diaphragm, but none had active tuberculosis. In another year, of 63 nurses examined, 11 had positive Mantoux tests and none had signs of active tuberculosis.

Of the total of 413 nurses examined in these three hospitals, only six cases of tuberculosis were found, or a percentage of 1.45.

While this percentage of tuberculosis in our nurses is regrettable and probably can be lowered, it is much less than the incidence found in other communities. Dow (4) states that among nurses in training this percentage is at least 6 in Canada, a discrepancy in the two localities which points favorably to the care given our own nurses in Newark.

Koch, in 1884, performed the necessary step of isolating from tuberculous lesions the causative organism. The bacillus can be grown outside the body in artificial medium for several generations and the growth from the last transplant will produce typical tuberculosis in suitable animals. It would then seem that the power of controlling the disease consists not only in finding the cases but in isolating them and destroying all of their discharges. Further quoting Koch, numerous experiments have shown that the inhalation of scattered particles of phthisical sputum causes tuberculosis with absolute certainty, not only in animals easily susceptible to the disease but also in those who have much more power of resistance. The tubercle bacillus will survive for a long period of time in dried sputum, so that particles of infected sputum accidently falling on bed linen, the outside of cups, etc., may dry, become pulverized, and be present as dust particles charged with living bacilli in the air to be inhaled by anyone who happens to be present. The factors which determine the conversion of latent infections to manifest clinical disease are fatigue, overwork, malnutrition, and overcrowding. The evidence of Ross and others tends to show that the incidence of tuberculosis among nurses is greater than among women of the same age in other occupations. This point, however, is difficult to evaluate because nurses are more easily available for frequent observation and examination than other groups.

According to a League of Nations report, the death rate from tuberculosis in Germany, in 1913, was 157 per 100,000, and in 1918, after the war, 287 per 100,000.

In Germany at the beginning of the twentieth century, tuberculosis caused 223 deaths per 100,000 or two and one-half times that of four other infectious diseases, *viz.*, typhoid, measles, scarlet fever, and diphtheria. Thirty years later, deaths from the four other contagious diseases had fallen to one-quarter; deaths from tuberculosis had fallen to one-half. Thus, 30 years later, tuberculosis now causes five times as many deaths as the other four contagious diseases put together; not only that, 5 to 15 per cent of the cases of other infectious diseases are fatal, while 60 per cent of open cases of tuberculosis died within three years. Tuberculosis has, therefore, become the major contagious disease problem, especially among young women in the second and third decades.

A rather small number of factory workers was examined for tuberculosis, or other parenchymal changes which might render sandblasting in their cases extra hazardous, but we think it advisable to include them in this report.

These men were all husky-appearing individuals who were under more or less constant medical supervision by a staff of doctors. Those who were assigned to the work of sandblasting were examined to determine whether or not their lungs were impaired to any degree whatsoever recognizable by x-ray examination which presumably would render them more liable to silicosis. On account of their generally robust physical condition, it would not be expected that many cases of active unsuspected tuberculosis would be found. As a matter of fact, however, three individuals of a total of fifty examined were found with sufficiently suspicious positive findings to cause us to recommend that other employment be given them. One of these was suffering from an active pulmonary tuberculous lesion. The others showed signs of healed tuberculous lesions with calcification in the peripheral portions of the lungs.

TABLE V.—EXAMINATIONS AND RESULTS

Year	Employees Examined	First Examinations	Repeat Examinations	Total Examinations	Silicosis	Tuberculosis
1932	11	11	0	13	0	1 (healed)
1933	7	5	2	7	0	1 (active)
1934	10	9	1	12	0	0
1935	9	8	1	17	0	0
1936	17	10	7	22	0	1 (healed)
1937	23	11	12	37	0	0
1938	11	3	8	13	0	0

Those individuals not showing any lung impairment and more or less constantly employed in sandblasting were re-examined from time to time to determine whether or not their lungs were affected as a result of their occupation, as indicated by a chart appended hereto. This indicates that 121 examinations were made of 50 individuals. Twenty-six were examined once, including those with tuberculosis; eight were examined twice; eight were examined three times; one was examined four times; two were examined five times; one was examined seven times; two were examined eight times, and two were examined nine times.

Those free of any pathology showed no increase in the density of the parenchymal shadows during the several years in which they were sandblasting, which may indicate the effectiveness of the protective measures utilized in the plant to prevent the inhalation of dust particles and development of silicosis. One individual developed an enlargement of 7 mm. in the greatest transverse diameter of the heart between the examinations of May and November, 1938. The cause of this is under investigation, but in the absence of any lung lesion it was not believed to be due to the irritation by dust.

DISCUSSION

One of the objects of this paper is to emphasize the unexpected finding of tuberculosis in a large number of supposedly well people who had, immediately preceding an x-ray examination, passed a satisfactory physical examination. We have cited instances in which people have lost little or no time from work for years and yet were, by chance, found to be suffering from tuberculosis of one or both lungs, with cavitation and markedly positive sputum. Six per cent of the healthy male factory workers, examined only because they were about to be transferred to work known to be hazardous, were also found to show signs of sufficient gravity to prohibit the transfer to the new work.

It is probable that more than 1 per cent of our readers, although considering themselves well, would be discovered to have either tuberculosis or some other serious lesion in their lungs if they submitted to an x-ray examination. This opinion has been forced upon us by the records of the Prudential Insurance Company and our own observations since Sept. 1, 1934. Inasmuch as the greatest good and the most rapid cures are made only when the lesions are discovered in their earliest stages, we must take an active part in urging even those who feel well to occasionally submit to an x-ray examination of the lungs. This becomes more urgently necessary if a person has frequent colds or feels tired to an unusual degree without known cause. The general practitioner can do more in this matter than the specialist, for he is ordinarily the one to first contact the patient. The roentgenologist can examine only those referred to him for the purpose, but he should, when opportunity offers, keep other physicians reminded of the insidious onset of this dread disease. Also, that in very early lung involvement the roentgenogram produces evidence which is often pathognomonic and indisputable, and the early diagnosis aids in reducing the mortality and morbidity of this centuries-old scourge.

SUMMARY

1. The general incidence of tuberculosis is not considered in this paper.

2. About 1 per cent of those who considered themselves well and whose lungs were x-rayed, were found to have active pulmonary tuberculosis or some other pathology.

3. A small group of 50, working at sandblasting over a five-year period and using protective masks, etc., did not develop any demonstrable lung pathology as a result of the extra hazard.

4. The public health would be better protected if lungs of "healthy" persons were periodically x-rayed.

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THE ROENTGEN DIAGNOSIS AND TREATMENT OF CARCINOMA OF THE LARYNX AND PHARYNX[1]

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CANCER of the larynx, next to cancer of the skin, breast, mouth, and uterus, gives to us probably the greatest hope of cure with our present knowledge, providing the diagnosis is made early and the lesion is treated skillfully and thoroughly from the beginning. The diagnosis in its earliest and most curable stage is probably not best made by the roentgen rays. The earliest diagnosis I believe can best be made by direct or indirect laryngoscopy. This requires that the patient be brought under the supervision of a skillful laryngologist or bronchoscopist at the onset of the symptoms. The earliest symptoms are hoarseness or local discomfort. These may or may not be associated with pain, soreness, or tenderness. It should be our aim, therefore, to have these patients obtain this expert opinion by the end of two weeks if there is no improvement during this time. Intermittent hoarseness may be due to carcinoma. It is well known that if the diagnosis is made while the lesion is still intrinsic, and the patient is operated upon skillfully, as high as 85 per cent of the intrinsic group has been reported as cured by laryngofissure (Jackson and Jackson, Tucker, Clerf, Gluck, Sorenson, and others).

Tucker, in a study of 200 consecutive cases of carcinoma of the larynx, estimated that at the beginning, 72 per cent were intrinsic, and, therefore, operable. However, as patients now come to the expert laryngologists, the great majority has become extrinsic. Of 280 cases *operated* upon and reported by Nager, Schinz, and Zuppinger, only 23 (8 per cent) were recorded as intrinsic. This would represent a much lower percentage if the inoperable cases are included. Of the 280 cases operated upon, only 11 survived operation from one to nine years (4 per cent). Of these 11 recovered cases, six were classed as intrinsic. Of the cases treated by irradiation (involving a more advanced and usually inoperable group), about 25 to 28 per cent should recover. On this point, Chevalier L. Jackson, in a personal letter, says, "Between the years 1930 and 1937, we saw 347 cases of cancer of the larynx. Of these, 71 (11 per cent) were thought to be of the very early and limited intrinsic sort which are regarded as suitable for the conservative operation of laryngofissure. An additional 79 were operated upon by laryngectomy, but some of these cases were not really suitable cases for surgery, perhaps." Jackson and Jackson find more and more indications for treatment by irradiation, and say, "The greatly increased efficiency of irradiation indicates that laryngectomy should now be limited to good surgical subjects of good general expectancy." In this small early group of cases, therefore, it is not likely that the radiologist will be needed for either diagnosis or cure. It is possible, however, to cure even the early cases by irradiation (Schinz, Stewart-Harrison, Torrigiani, and Palumbo), but it is probably not the most economical nor the most efficient method of treatment. Unfortunately, the great majority of patients do not reach the expert laryngologist or bronchoscopist in this early stage, and then the diagnosis and the differential diagnosis becomes more difficult and the problem of treatment more complicated and more serious. No special method of treatment and no special technic can make up for the disadvantages of late

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D., who has himself written, in collaboration with S. M. Baum, an excellent article on "Roentgen Diagnosis and Treatment of Laryngeal Neoplasms." *Laryngoscope*, St. Louis, **44,** 144–166, February, 1934.

diagnosis and late treatment. Remarkable advances have been made in the radiological treatment of carcinoma of the larynx even in the later stages, but the best results obtained in the later stages are not one-third as good as those obtained while the disease is still intrinsic.

Roentgen Diagnosis.—The skillful roentgenologist can furnish valuable information in all cases of carcinoma of the larynx, but in those cases in which the disease is no longer confined to the cords, and in those cases in which the disease is no longer in the earliest stage, a roentgen study is absolutely necessary. The laryngologist can see the surface of any tumor but a skillful roentgenologist can show usually the outline of the entire tumor and can furnish considerable information as to the conditions of the surrounding tissues. The movements of the larynx and the swallowing function and their disturbance by infiltrating carcinoma can be best determined by the roentgenologist. Pancoast and Pendergrass deserve credit for an excellent description, in 1930. A fluoroscopic study is, therefore, absolutely necessary, as well as roentgenograms. A roentgenogram should be made laterally with the tissues relaxed, then one should be made with an obstructed forced expiration (made with patient's nostrils and mouth closed). The patient should then be given a level teaspoonful of a concentrated barium mixture (Rugar is satisfactory). This can be moved about the mouth and then swallowed, so as to fill all crevices and lateral spaces. A film

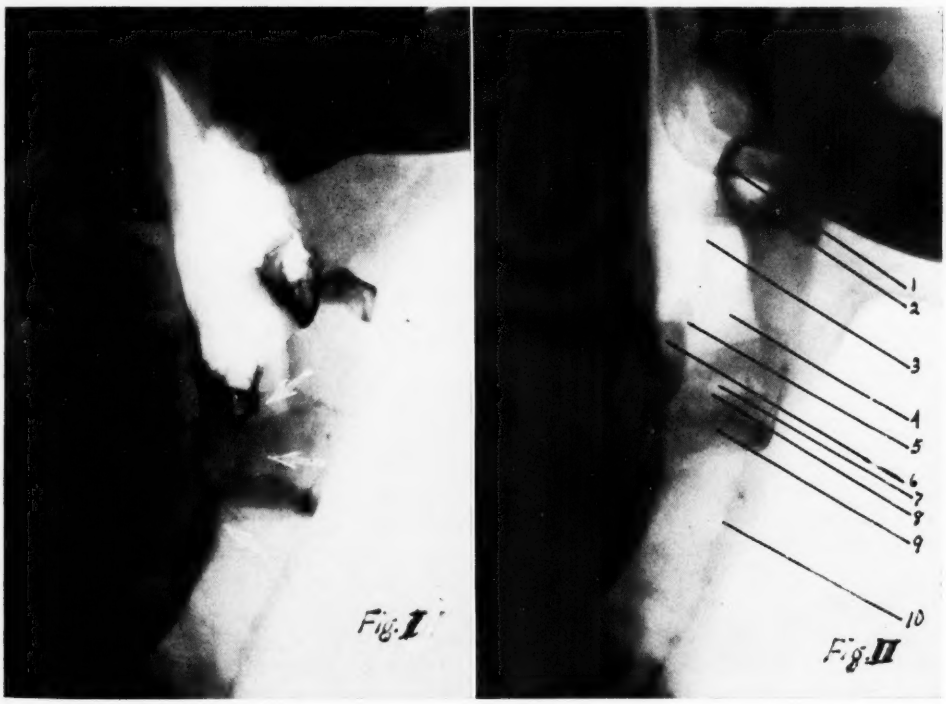

Fig. 1. Shows carcinoma involving the arytenoid region, the laryngeal vestibule, the ventricle, the cord, and posterior portion of the larynx, causing an opacity in the posterior two-thirds of the larynx, indicated by small arrows. Lateral view made before radium and x-ray treatment.

Fig. 2. Shows the same case eight months later, with complete absence of all evidence of disease—normal. Notice the complete transparency of the laryngeal vestibule, the smooth outline of the arytenoids, the smooth normal appearance of the ventricle, the smooth vocal cord, and, in fact, everything normal. These normals are as follows: 1. epiglottis; 2. valleculæ; 3. aryepiglottic fold; 4. laryngeal vestibule; 5. arytenoid; 6. pyriform sinus; 7. ventricle; 8. vocal cord; 9. cricoid; 10. trachea.

should then be made laterally, with the tissues in a relaxed position. Then one should be made with the tongue pushed forward as far as possible and held between the teeth. Another film should be made in the postero-anterior direction so as to obtain the view of the filling of the valleculæ, and additional information can be obtained with regard to the cords and ventricular spaces and pyriform sinuses. This position is especially valuable in a study of a tumor of the pharynx, pyriform sinuses, or upper end of the esophagus. If there is a lesion in the pharynx or upper portion of the esophagus, it is an advantage to make several films in the lateral view during the act of swallowing. This is best done with a high milliamperage outfit (500 to 1,000) so as to make the film at a distance of from six to eight feet in a thirtieth of a second. It is always an advantage to make the films at the greatest distance possible, with the shortest time of exposure, and the finest focused tube possible, in order to obtain the greatest amount of detail.

The lateral projection (Figs. 1 and 2) is especially valuable in the study of the transparent areas of the pharyngeal vestibule, the laryngeal vestibule, and the larynx, including the epiglottis, the aryepiglottic fold, the arytenoids, the true and false cords, and the space between the cords called the laryngeal ventricle. Barton Young describes this space as being "Zeppelin-shaped or cigar-shaped during the phonation 'e,' and is bounded above by the false and below by the true vocal cords." These ventricles and the tissues in the upper pharynx are best shown in a film made with obstructed forced exhalation.

This subject has been well discussed by a number of authors, but particularly by Hay and by Young. Especially when dealing with tumors involving the pharynx, it is important to take into account the soft-tissue space located posterior to the larynx and trachea. This space has been well studied in normal subjects by Hay and tabulated by Young. It should be kept available for constant comparison, as is shown in Table I.

TABLE I.—UPPER NORMAL LIMITS OF SOFT-TISSUE SPACES OF NECK

Age	Post-pharyngeal Soft Tissue		Post-laryngeal Soft Tissue		
0.1	1.5 c[2]		2.0 c		
1–2	.5 c		1.5 c		
2–3	.5 c		1.2 c		Post-ventricular
3–6	.4 c		1.2 c		
6–14	.3 c		1.2 c		
	Male	Female	Male	Female	
	0.3 c	0.3 c	0.7 c	0.6 c	Post-cricoid

[2] c is anteroposterior dimension of fourth cervical vertebral body measured at its middle.

Figure 2 is a composite illustration of a normal neck and soft-tissue spaces, and together with Table I (May) will be found useful for reference in making roentgenograms of the neck, when in doubt as to the normal. (PP) represents post-pharyngeal soft tissue, usually measured at a higher level than shown here. (PC) is the post-cricoid soft-tissue zone (Young).

Anteroposterior Study.—The value of the anteroposterior study (Fig. 3) or the postero-anterior study of the larynx and pharynx has been, I believe, greatly neglected. Young deserves a great deal of credit for demonstrating the advantages of this position, which is valuable both for roentgenograms and for fluoroscopic study. During fluoroscopic study, one may observe the movements both laterally and postero-anteriorly during phonation and during the act of swallowing. Disease will often cause lateral deviation of the food passage and in the lateral view any displacement or distortion of the normal passage anteroposteriorly can be observed, and, of course, can be recorded on the roentgenogram. If one will familiarize himself with the fluoroscopic observation of the movements of the cords in the postero-anterior view and in the lateral view and the movements of the larynx, as well as symmetrical filling of the crevices about the larynx, it becomes more easy to recognize any defect or fixation which is due to carcinoma. The postero-anterior

view is especially valuable because of the possibility of comparing one side with the other. If these cords approximate well and move equally, there, of course, is no fixation and probably no infiltration present. Likewise, if one gives an opaque mixture, the filling of the vallecular recesses and pyriform sinuses can be visualized, and then can be recorded by instantaneous roentgenography on the photographic film. Tomography will give additional information.

Carcinoma of the larynx is usually suspected when there is pain, swelling or soreness, or difficulty in swallowing, or when the patient expectorates blood. Nearly all of these symptoms indicate a rather advanced lesion. It is common for a patient to complain of sore throat, and certainly one does not think of malignant disease every time a patient develops sore throat. Most of these "sore throat" cases are due to inflammation of the tonsil or an inflammation of the pharynx or larynx, but when the symptoms continue during two or more weeks without any improvement, it is wise for the physician to think of the possibility of newgrowth. This is particularly true when the symptoms are located on one side, for, as is well known, tonsillitis commonly affects both sides and a pharyngitis is more or less general. A localized pain, swelling or soreness, therefore, must make one think of some disease which gives a local effect, naming particularly malignant diseases, syphilis, and tuberculosis.

The upper pharynx can be examined completely by the laryngologist, and certainly his studies of the nares, the posterior nares, and the upper pharynx are more conclusive than the roentgen studies. However, when once the laryngologist has made a report on a carcinoma involving these upper pharyngeal areas, the roentgenologist still can add considerable information by determining the upper and anterior limits of any tumor. It is important for the roentgenologist to determine whether or not the tumor has extended up into the sphenoid, ethmoid, or upper nasal passages, and whether or not it has extended into the maxillary antrum. In these cases, too, he can determine to a considerable extent the degree of infiltration as judged by the mobility permitted of the pharyngeal muscles. When a lesion involves the lower pharynx or upper esophagus or the laryngeal area, the roentgenologist can furnish very valuable information, for while the laryngologist can examine the upper surface of the tumor in these regions, it is often impossible to see the lower limits of the disease. Generally, the laryngologist or bronchoscopist demands all the information possible from the roentgenologist before he attempts bronchoscopy or direct laryngoscopy. Tomography is especially useful in outlining the disease below the cords in the transverse plane.

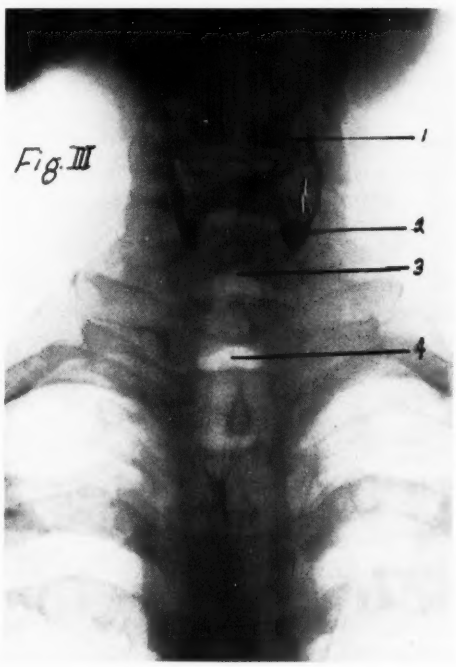

Fig. 3. Postero-anterior view of the larynx; 1. Valleculæ—unequal filling, irregularity in outline, displacement, indicates disease. 2. Pyriform sinuses—they may fill unevenly or there may be filling defect, usually due to tumor; they may be displaced in relation to the median line. 3. Vocal cords—these can be observed fluoroscopically and during phonation, one can observe the free mobility of the normal or the fixation of the diseased cord. 4. Transparency due to the air in the trachea.

Malignant disease involving the lower pharynx or the upper esophagus gives difficulty in swallowing and involves both pain and actual mechanical difficulty in the passage of the food over the tumor. A lateral view in such a case, taken before giving any opaque material, may show an increase in the shadow of the soft tissue involving the post-pharyngeal and post-laryngeal space. The administration of a dense opaque barium mixture will then outline more clearly the lumen of the lower pharyngeal space and the upper esophagus, and will commonly show irregularities of the outline of this space as compared with the normal smooth surface. The postero-anterior view, both fluoroscopically and in roentgenograms, will show the irregular outline of any tumor tissue. The barium is apt to settle into the small crevices which outline the tumor and thereby outline the details of the tumor. If one is prepared to make instantaneous roentgenograms in the lateral view during the act of swallowing, the actual lumen of the esophagus in this region can be determined. If the patient is placed in the right anterior oblique prone position and on a tilt table which permits the head to be at a lower position than the lower part of the esophagus, it is, at times, possible to outline the lower border of the tumor in the esophagus as well as the actual lumen.

Cancer of the larynx is recognized roentgenographically by the opacity which it causes in the transparent laryngeal space. This may be seen at times fluoroscopically but is usually seen more clearly in the roentgenograms, providing fine detail is obtained. In addition to this, one can observe irregularities in even an early case on the two sides of the larynx by irregular filling of the valleculæ or the pyriform sinuses, and one can observe irregularities in the action because of the infiltration, fixation, and increased opacity of the tumor tissue involving the pharyngeal vestibule or the laryngeal vestibule. The tumor may originate in or extend to the vallecular space or the pyriform sinus, in which event it would displace or prevent the opaque material from finding its way into this space. As previously indicated, a tumor of an infiltrating character is apt to fix certain parts of the laryngeal tissues or the larynx itself and interfere with the normal movements of the larynx. Likewise, if a tumor originating primarily either in the larynx or in the pharynx has infiltrated any of the muscles, the movement of these muscles is interfered with, or a tumor involving one or both of the arytenoids may cause an increase in volume, or, if it is in an advanced ulcerating stage, it may show destruction of one or both of the arytenoids. The disease may involve the epiglottis or the aryepiglottic folds which would then not only interfere with the movement of the epiglottis but would also show an irregularity in outline. The space between the epiglottis and base of the tongue is normally smooth in outline, but when ulcer or tumor is present this outline is disturbed and can be easily recognized.

Roentgenograms made at the beginning of treatment serve as permanent records and can be used for comparison later as the case progresses toward recovery under radiation therapy.

Indications for Radiological Treatment.—The radiological treatment of carcinoma of the larynx and the pharynx must be individualized. Therefore, an accurate diagnosis by the laryngologist or bronchoscopist, combined with most careful studies by the roentgenologist, is absolutely essential as the first step to be taken in the treatment and management of tumors located in these regions. In the earliest stages, the laryngologist or bronchoscopist must determine the exact location of the disease, its extent, the mobility of the vocal cords, and obtain what information is possible as to the mobility of the surrounding tissues. He must do a biopsy, either immediately or after a few preliminary x-ray treatments. When these tissues have been examined carefully by a skillful and well-informed pathologist, the general characteristics of the tumor can be determined and a reasonable estimate can be

made by the pathologist as to its radiosensitivity which he will probably grade as I, II, III, or IV, the fourth grade being the most malignant and usually inoperable. This estimation of the radiosensitivity made by the pathologist is helpful but it must not be accepted as the final word. If the pathologist estimates that the tumor belongs to Grade I or II, and the case is still in an operable stage, this evidence will favor operation, but if the disease has extended beyond the operable stage, or if there are contra-indications of a general character to operation, the patient must not be condemned to die without an effort to treat this disease by irradiation. On the other hand, if the pathologist grades the tumor as III or IV, and the disease has extended to the doubtfully operable stage, then this evidence would favor radiological treatment in preference to surgery. New and Waugh obtained no five-year recoveries in the six operable cases belonging to Grade IV. It is my opinion that all borderline operable cases should have a moderate amount of preliminary x-ray treatment before operation, because pathologists have found that while the general characteristics of the tumor, as studied microscopically, point toward one of these four grades, there are likely to be some of the cells belonging to Grade III or IV in the tumor, or at the border of the tumor, which may not be seen in the microscopical specimen, and the presence of these cells may lead to failure. Preliminary irradiation will likely devitalize the more malignant cells, thereby placing the case more definitely in Grade I or II, and, I believe, improve the end-results of operation.

I would estimate that from 900 to 1,200 r units delivered into this tumor tissue preceding the operation would delay the operation probably only one or two weeks, and would be more likely to be followed by permanent success. It is also my opinion that when dealing with an advanced carcinoma, it would be advisable to give such preliminary irradiation before doing a biopsy. This view is also held by Webster. All experienced radiotherapists have found that at times an advanced intensive infiltrating or radioresistant tumor responds to irradiation when, on theoretical basis, it was estimated that there would be little or no response. This determining factor has not yet been discovered. Coutard, in a masterful analysis of his five- and ten-year results in his most recent communication, has tried to determine the likelihood of response to irradiation. He has found that the supraglottic tumors are frequently accompanied by adenopathy, while those of the vestibule or ventricular cavities are more rarely accompanied by adenopathy, and those of the glottis are never accompanied by adenopathy. He also states, "We now know that cancers of the undifferentiated cells, extremely fragile, can be cured by all varieties of irradiation, while cancers of very differentiated and infiltrating cells are only exceptionally cured."

He says further:

"If, for example, the hemilarynx is totally immobile, if the muscles are infiltrated by the neoplasm, if the arytenoid cartilage is totally fixed, the radiosensitivity is low, the possibility of cure is reduced. One thus has generally a very differentiated cancer.

"If, on the contrary, the muscles remain free, if the cords, bands, and arytenoid cartilages have only a slightly reduced mobility, then even if the tumor is voluminous, necessitating a tracheotomy, and has destroyed part of the thyroid cartilage, it is possible to obtain a cure in a great many such cases. These are, in general, cancers formed of only slightly differentiated cells, and more often of mucous membrane type."

He calls attention to the fact that the neoplasm as a whole may seem mobile but may be infiltrating at the point of origin, which can be appreciated only from fifteen to twenty days after beginning treatment. This illustrates the necessity of constant co-operation of the laryngologist (unless the radiologist is especially trained, Webster) in observing these cases during treatment. Dividing the cancers into anterior, median, and posterior, Cou-

tard has found that the median are more easily curable, the anterior area are less often curable, while the posterior group are rarely curable by irradiation.

Technic of Radiological Treatment of the Larynx.—When one thinks of technic in relation to the treatment of carcinoma of the larynx, the Coutard technic naturally comes to mind, but the Coutard technic is not a definite procedure. Dr. Coutard has been varying his technic almost continuously during the past 15 years, both in general management and in its application to the individual case. All radiologists look upon him as a leader and appreciate his contributions and his frank, sincere, and scientific investigation of the problems connected with the treatment of carcinoma of the larynx. The casual reader, however, would get the impression that the Coutard technic is a definite procedure and is somewhat similar in its application to that which is used in radiography, in which we can use a certain number of milliamperes at a certain distance, with certain voltage, for a certain time, in relation to the variable thickness of the part examined, and our photographic effects will be almost uniform.

The treatment of carcinoma of the larynx is a very complicated procedure and while Coutard has developed or has continued the development and study of prolonged fractional dosage, the factors as to unit dosage, total dosage, interval, number of applications, portals of entry, and filtration have been very variable and from a recent communication from him there has been considerable variation, even since his last publication.

The general principles governing the treatment of carcinoma of the larynx, as well as carcinoma elsewhere in the body, are:

1. There should be given sufficient dosage to destroy the cancer cells.

2. The dosage should be given in such manner that it will destroy the cancer cells without destroying the normal tissues.

3. The treatment must be given in a period of time short enough to prevent the development of radioresistance on the part of the cancer cells.

4. The treatment must be prolonged and given in such dosage that it will not seriously damage the normal tissue.

5. The normal tissues must be conserved in every way possible, and the portals must be large enough to cover all disease, but should not greatly exceed this area.

The various authors have been trying to combine these principles along the lines of variable theories. This has led to the many so-called "modified Coutard technics." In practice, the Coutard technic differs little, if at all, from the so-called "saturation technic" which I have utilized and described previously. Both involve prolonged fractional dosage, with a gradual build-up to the limit of normal-tissue tolerance, and, in actual practice in my own hands, has differed very little. In actual practice, previous to Coutard's work, I did not carry my treatment to the extent of a definite destructive epithelitis which I now think is usually necessary but undesirable.

1. To bring about destruction of the malignant cells, it would be desirable to apply the irradiation in the shortest time possible. This, however, endangers the normal tissues, as a general rule. When the cancer cells are of the radiosensitive type, which means that they are undifferentiated, a much lesser dosage is needed to destroy them, and, therefore, the treatment can be given in a shorter period of time, and it is probably desirable to give this treatment in a short time. As the cells become less and less differentiated, such as one finds in Grades III, II, and I, they resemble ultimately in their resistance, the normal tissue cells. One must, therefore, prolong the irradiation so as to make use of a slight differentiation between the normal and the diseased cell. This slight differentiation is due to the fact that the normal-tissue cells have a better organized blood supply which brings about more rapid and complete repair of the damage done by smaller doses continued over a

longer period of time. The cancer cells, on the other hand, having a less well organized blood supply, have less chance of recovery from the damage done by the same relatively small doses given over a prolonged period.

It is also well known that malignant cells are more easily destroyed during the process of division. Therefore, if the radiation is given even though in small dosage at the time of cell division, destruction is more likely to take place. This has led Coutard to recommend low intensity dosage, and he aims to give not more than five or six r per minute. I have attempted to reach this same objective by the use of radium packs, not given during a few hours, as is used with the radium bomb (Edling), but given by packs applied continuously during the entire 24 hours. I have had some satisfactory results in patients treated entirely by such radium packs. This represents the ideal method of applying a prolonged continuous treatment, whereby one obtains the greatest differentiation between the sensitivity of the normal tissues and the diseased tissue.

2. In our effort to destroy the cancer cell without doing serious damage to the normal-tissue cell, the continuous application of irradiation from a radium pack during 24 hours furnishes the ideal method. I have made such continued applications for as long as four weeks, alternating from the right to the left side of the neck. It is my opinion, and it has been the observation of other clinicians, that there is an increased differentiation in the effect upon the cancer cell as compared with the normal-tissue cell, as one makes use of shorter and shorter wave lengths, such as is obtained by increased filtration with radium. It has been my custom, therefore, to utilize two millimeters of platinum filtration, which is the equivalent of four millimeters of lead. This enables one to utilize only the hardest (86 per cent) of the gamma rays. Thus by combining the continuous irradiation, with the object of destroying the cancer cells during the process of division, and by using the higher filtration, there is greater differentiation in the effects between the normal tissue and the diseased tissue. The objection to the use of radium is the relatively smaller depth dose due to the short distance, as compared with the greater depth dose obtained from highly filtered roentgen rays, which can be used at a greater distance. It is fortunate, however, in the treatment of carcinoma of the larynx, that we have only about three and one-half to four centimeters depth dose to the median line, and, therefore, to the central portion of the larynx. Consequently, it is not difficult to get an efficient dosage at this depth, due to the advantages described heretofore. One can further protect normal tissue in relation to the cancerous tissue by utilizing as small a field as possible. The use of small fields has also been emphasized by Martin. This, of course, requires accurate diagnosis as to the extent of the disease, both primary and any secondary disease that may be present. It also gives a tremendous advantage when one can treat these lesions in an early stage, because one can utilize a smaller portal. It is my aim, therefore, to utilize as small a portal as is possible to cover the total area of known disease. This preserves the normal tissue and increases the relative destruction of the cancerous tissue.

3. In choosing a technic with the object of destroying the cancer cells before sufficient time has developed for radioresistance, one must individualize, to a great extent according to whether or not infection is associated, and according to whether or not there is danger of edema, which would lead to closure of the glottis, demanding a laryngotomy. This thought again favors the use of radium at the beginning, because a gradual and safe effect is obtained. I have never seen any suggestion of such edema having been produced by the radium applications. After from four to ten days of continuous application of radium, it is probably desirable to give the high voltage or supervoltage x-rays, highly

filtered, utilizing the right and left posterior cervical portals, posterior to the portal used for the radium, thereby getting an increased effect upon any glandular distribution, and, at the same time, bringing about a greater depth dose by cross-fire upon the laryngeal tumor. This helps to overcome the objections of massive doses at the beginning, and yet accomplishes the desirable results with regard to sufficient dosage within the first two weeks. Recently, therefore, my technic has been to give about half of the total irradiation with the radium packs, and the other half with high voltage or supervoltage roentgen rays. I think no one can lay down any rules. It is a matter of skill and judgment. In general, it is my present impression that if this treatment is varied so as to utilize the radium packs half of each week and the roentgen rays during the other half, it will probably bring about the best results.

Fig. 4. Upper photograph shows the arrangement of the radium with two 10 mg. units at each end and 3 mg. units underneath the lead covering. This is then placed transversely at the site of the neck overlying the disease. Lower photograph shows the same pad tilted on a cork showing the increased thickness of 1 cm. anteriorly.

4. The combination of radium packs with roentgen rays, as suggested in the foregoing paragraph, and as described in detail, subsequently, enables one to prolong the irradiation safely during a period of six weeks. Coutard has found by his careful analysis that, in general, this is the best period for the optimum results. It must be borne in mind, however, that with the more sensitive types of tumors, the irradiation can sometimes be given to advantage within from two to four weeks. Safety in this period of time lies in the fact that the total radiation need not be so great as is necessary when dealing with the highly differentiated type of tumor.

Radium Pack.—The radium pack was originally made up in the form of a cast fitting the neck, using the Columbia Paste, as recommended at the Curie Institute. This was cumbersome, stiff, and more or less of a burden for continuous wear over long periods. I therefore developed a felt pad, measuring 4 cm. in thickness posteriorly, and 5 cm. anteriorly (Fig. 4). This is fitted in such manner that it makes the distance from the median line of the body to the radium approximately the same both anteriorly and posteriorly. It is estimated, therefore, that approximately the same amount of radiation will reach the sagittal plane extending directly through the middle of the larynx both anteriorly and posteriorly. This pack measures 8 cm. vertically, and 10 cm. anteroposteriorly. When dealing with an early or localized lesion, it will be an advantage to utilize a circular pad from 6 to 8 cm. in diameter (Fig. 5). This can be made up with a cover of 3 mm. of lead and a rim of lead 3 mm. thick extending toward the skin 2 cm., which will partially control stray irradiation and will permit a considerable increase in the total local dosage. On the outer surface of this pack, we usually distribute ten 10-

milligram tubes, each measuring 20 mm. in length and 5 mm. in diameter. The radium is filtered through 2 mm. of platinum, and these tubes are placed two on each edge, approximately 1 cm. from the border, and two in the middle to partially control the irradiation upward toward the face and downward toward the clavicle. I have used an angle of 3 mm. of lead over the upper and lower borders, so as to protect the tissues above and the clavicular region below. Sufficient cotton is placed about the lower border so as not to irritate the clavicle. Arranged in this manner, this radium pack gives 25 r per hour at the contact surface with the skin. At 3.5 cm. in depth—the median line and tumor depth—it would be approximately 10 r. Edling uses 1,250 mg. bomb with only 2 mm. lead equivalent, with which he estimates 40 per cent at 3.5 cm. depth. I have 1,250 milligrams of radium but prefer to use this smaller quantity so as to get continuous irradiation. His surface intensity is, therefore, nearly ten times as great (35.5 Imc.).[3] The patient's head and neck are bandaged so that the adhesive plaster can be applied without irritating the skin. The pack is then bound firmly with adhesive strips running around the neck and with strips over the head. The pack is applied for 24 hours on one side of the neck, and then for 24 hours on the opposite side. The patient is confined to his room but not to bed. The number of applications vary somewhat with the conditions present, both with regard to the patient's physical condition and to his living circumstances. Sometimes the radium is applied for from six to eight hours daily and he is treated in conjunction with the high voltage x-rays. We aim to make from 12 to 16 such radium pack applications for the reasons discussed above. This is supplemented on intervening days with applications of high voltage or supervoltage x-ray treatment, until the estimated amount of irradiation required has been given. After about four weeks, there is very definite redness and desquamation in the epithelium of the skin, and a deep reddish or whitish appearance of the mucous membrane. It is my opinion, however, that there is less damage to the skin and a less violent reaction in proportion to the radiation effects given in this manner, than when the irradiation is given entirely by means of the roentgen rays.

The surface dosage with the radium pack amounts to from 28,000 to 36,000 milligram-hours. The dosage with 200 kv. roentgen rays, filtered through 2 mm. Cu and 2 mm. Al, or the equivalent Thoraeus filter, amounts to from 3,000 to 4,000 r units, given at the rate of 14 r per minute and 250 r per day.

Results of Treatment.—The treatment

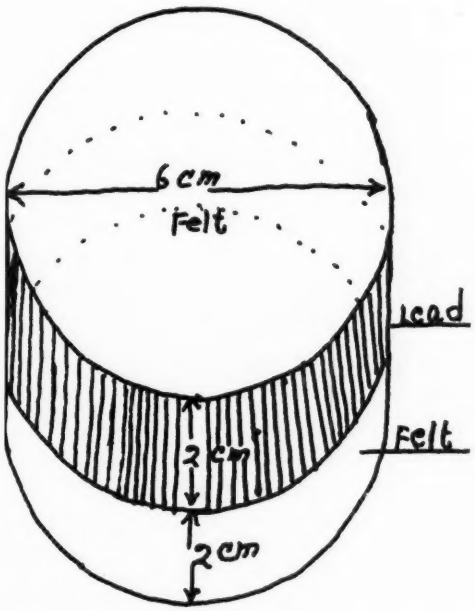

Fig. 5. Shows a circular arrangement with the distribution of the radium capsules around the border under a layer of one-eighth inch of lead, and the upper portion surrounded by one-eighth inch of lead, so as to control some of the stray radiation. This is useful for smaller areas of treatment, not exceeding 6 cm.

[3] One Imc. expresses 0.001 of the intensity produced by 1 gr. radium, filtered through 0.5 mm. platinum only, at a distance of 1 cm., the radium preparation being so small that the source may be considered as a point.

described produces a moderate grade of epidermitis, with desquamation of the epidermis, but usually no vesiculitis or ulceration of the skin. A moderate degree of epithelitis of the mucous membrane is also produced, but it seems to me there is definitely less disturbing effect on the skin, mucous membrane, and normal tissue, in proportion to the effect on the malignant disease, than when treated by roentgen rays alone. With this management, there seems to be less disturbance of the general health, such as nausea, vomiting, prostration, but one does have dryness of the mouth and throat associated with sticky mucus. I have gotten some relief from the sticky mucus by giving the patient a teaspoonful of essence of caroid, taken as often as necessary. I have found aquaphor useful, as recommended by Kaplan, spread upon gauze and applied twice daily over the epidermitis. An alkaline antiseptic gargle and mouth cleanliness is also helpful in the management of the epithelitis of the mucous membrane.

From a statistical standpoint, no one has had as much experience as Coutard, and no one has analyzed his cases so carefully. In spite of his extensive experience, his results have varied from no "five-year recoveries" for the year 1922, to 66 per cent for the year 1932, yet 1921 gave 50 per cent and 1929 only 14 per cent. Therefore, the variable results are not merely a matter of experience or progressive improvement in technic. No one has been more studious or critical of his technic than Coutard. His average results for the years from 1921 to 1932, during which he has treated with roentgen rays and obtained 39 five-year recoveries out of 142 cases so treated, show 27 per cent of five-year recoveries. The fact that Coutard still insists upon the use of low intensity per minute has encouraged me to write this brief report, hoping that someone having a large amount of material may be able to prove its value statistically, which I have not done. I present this, therefore, for what it is worth, drawing no conclusions.

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PNEUMATIZATION OF THE MASTOID[1]

A ROENTGEN STUDY

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THIS communication purposes to trace the growth and development of the mastoid radiographically; to correlate roentgen findings to anatomic and clinical conceptions, and to elaborate on a recently proposed anatomic classification based on pneumatization.

The present classification of mastoids as pneumatic, diploic, or sclerotic is neither sufficiently informative anatomically nor of great assistance otologically. Although several excellent anatomic and histologic studies of the temporal bone and of pneumatization of the mastoid have been made, little has been done to correlate these studies to the actual radiograph of the mastoid, and to correlate the variations of pneumatization, as identified radiographically, to the variations in the clinical manifestations of mastoiditis.

GROWTH

The true mastoid process is evolved from the petromastoid part of the temporal bone, which becomes fused with the squamozygomatic portion of the squamous part and the tympanic part to form the entity known as the mastoid.

The squamozygomatic portion of the squamous part forms the outer wall and part of the tegmen of the attic and antrum. Radiographically, the squamozygomatic portion is visualized more clearly in the first two years of life than is the petromastoid. The latter, termed the "mastoid mass" by Cheatle (1), is a diploic bone; it offers itself to invasion by air cells which emanate and radiate from the area covered by the squamozygomatic bone. This area is the most important landmark on a mastoid film, and is termed the "peri-antral triangle." It encompasses the attic, aditus, antrum, and labyrinth, and corresponds to the base of the petrous pyramid; it covers the spaces which represent the center of activity in initiation and promulgation of pneumatization; it is also the first area to show signs of pathologic change.

The mastoid grows in three dimensions, its outline expanding from above downward, from before backward, and from within outward. Growth, as such, occurs under any and all conditions and is independent of pneumatization, except that with extensive pneumatization, growth is more expansive than with little or no pneumatization, in which case growth is somewhat limited. Growth begins at birth, accelerates between the ages of two and five, and is practically complete at six years, after which there is little demonstrable increase in the size of the mastoid.

PNEUMATIZATION

Concomitantly with growth, air cells develop in the normal mastoid by a process termed "pneumatization." This process is governed by vital and anatomic factors, the influence of which causes each mastoid to attain an individual cell pattern which differs from that of its mate and is sufficiently characteristic for actual identification.

Pneumatization has been the subject of considerable discussion in which many opinions and various theories have been expressed. Cheatle (1), Wittmaack (2), and Albrecht (3) are agreed that cell formation is initiated in intra-uterine life, Wittmaack placing the time as the fifth month. The middle ear and antrum from which cells develop are laid down and remain as one continuous cavity, the lining membrane of which is continuous with that of the Eustachian tube and nasopharynx.

Wittmaack describes the middle ear,

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

epitympanic space, and antrum as being filled with embryonic connective tissue which is gradually replaced by epithelial tissue before birth and during the first year of life; in the period between the first and fifth year of life, bone spaces in the mastoid become confluent, retaining their bone columns which extend into the lumens like "bone splinters"; the embryonic bone marrow is absorbed and replaced by subepithelial connective tissue, while the "bone splinters" grow and subdivide, thus generating new spaces. The building of bone spaces by confluency, with secondary invagination of mucosa, Wittmaack terms "eccentric-cell formation"; the subdivision of existing spaces by "bone splinters," he terms "concentric-cell formation."

Regarding the origin of cells that invade the mastoid, Wittmaack describes (*a*) a small number as coming from the epitympanic recess; (*b*) a majority as coming from the antrum, and (*c*) most of the terminal cells and those on the anterior surface of the mastoid as coming from the middle ear. This author states that the mastoid process should be completely pneumatized by the end of the fourth or fifth year, subsequent to which there is slow but unimportant continuation of pneumatization during the whole lifetime.

Albrecht believes that the degree of pneumatization depends on individual predisposition, such as the relation between the energy of the proliferating epithelium and the resistance offered to it by the surrounding tissue.

Cheatle believes that the formation of cells depends on the density of the separating layer of bone between the squama and the mastoid mass.

Proetz (4) thought the antrum and air cells to be a result of a plastic rearrangement of the skull, necessitated by the disproportionate growth of the cranium and associated structures, *i.e.*, cavities left by the separation of two walls of bone. To avoid physical disturbances, the cavities communicate with the external air by way of the nearest air cavity from which they arise, and are, therefore, lined with the membrane of that cavity. Proetz states also that air cells do not cross suture lines.

Eagleton (5), on the other hand, states that the stimulus resulting in pneumatic bone growth during infancy and early childhood is furnished by a rapidly proliferating surface epithelium from the upper respiratory tract. He believes that cell formation in the mastoid is to protect the labyrinth from external violence, and he terms the mastoid a neurocranial protective special-sense bone, which increases in size through the successive formation of additional small air-filled spaces. According to Eagleton, air cells occasionally do cross suture lines.

Koch (6) applies Wittmaack's theory to pneumatization of the nasal sinuses and states that when the mastoid is poorly pneumatized, the sinuses too are poorly pneumatized. This contention is not in agreement with the findings of Turner and Porter (7), who state that "the frontal sinuses, like the cellular mastoid processes, attain no distinctive size which can be said to be peculiar to any type of skull or to any race. The frontal sinuses, like the mastoid-cell area, show marked variations in size in individual skulls in the majority of races. An undeveloped frontal sinus is like an acellular mastoid; diploic bone is present in both. There is no evidence, either in individual skulls or in groups of skulls, that the frontal sinuses and the cellular mastoid spaces attain a similar degree of development."

Relationship between sinus and mastoid pneumatization has never been evident to the writer, who, in examining over 5,000 sets of mastoid and sinus films, has yet to find any significant similarity of pneumatization of either the nasal sinuses or the petrous pyramids and of the mastoid processes.

However, this brief summary of normal pneumatization does not account for the great variability in extent and pattern of mastoid-cell formation, particularly in individuals who have never had ear disease.

According to Cheatle's studies, which were purely anatomic by dissection, the

extent and pathways of pneumatization are determined by anatomic features and bone characteristics.

Wittmaack made anatomic and histologic examinations from which he concluded that the type of mastoid development was predetermined by pathologic changes in the mucosa, which resulted from trauma set up before, during, or after birth. He differentiates mucosal changes into two types: a hyperplastic type, the result of foreign body irritation, such as caused by amniotic fluid, vernix caseosa, and meconium, and an exudative type, which leads to fibrosis as a result of inflammatory reaction to infection of the infant ear. As sequelæ to these pathologic changes in the mucosa, various grades of disturbance of pneumatization obtain, depending on the type of inflammation, the degree of destruction of the mucosa, and the time of its occurrence. Wittmaack believes that the hyperplastic mucosa permits pneumatization to continue, but leads to irregularity of cell arrangement and eventually to sclerosis, whereas the fibrotic mucosa puts an end to pneumatization, without affecting the remaining spongy bone which appears diploic and not sclerotic. He contends that milder grades of fibrosis merely delay the process of pneumatization.

Albrecht calls attention to hemorrhage as a disturbing factor. In his studies of premature and new-born specimens, hemorrhages were observed in many, probably due to birth injury. Damage to the epithelial and connective tissue, such as infiltrative and inflammatory changes, could easily disturb and even inhibit pneumatization.

Nasal blockade in infancy, with resultant diminution of air supply and air pressure in the middle ear, is worthy of consideration as a possible factor in disturbance of pneumatization.

It seems quite significant that most of the specimens examined by investigators are either adult bones or those of the fetus and new-born infant. Because of this discrepancy in age of specimens studied and the absence of radiographic evidence of changes that occur in the living mastoid, it has been difficult for some investigators to accept Wittmaack's theories. Marx (8) questions whether examination of an adult bone, in which pneumatization is defective, entitles Wittmaack to assume as a fact that an infantile otitis was responsible for the defect. Marx feels that it is impossible to separate the hyperplastic and exudative forms of otitis. Wittmaack (9) replies to Marx with further evidence of histopathologic changes in the tympanic mucosa, reaffirming his original classification and asserting that the two forms may occur in mixture. He maintains that the hard, sclerotic mastoid results from hyperplastic infantile otitis and a total arrest of pneumatization at an early stage; he is unable to conceive a symptomless total destruction of epithelial lining with secondary ossification, and supports his view by stating that it has never been shown that a gradual sclerosis of the mastoid develops in the course of chronic suppuration of the middle ear. He does concede, however, that new bone formation is not uncommon in all forms of mastoiditis, whereby some pneumatic cells are obliterated by newly formed bone after necrosis of the epithelial lining.

Mayer (10), too, takes exception to some of Wittmaack's theory because he finds certain types of temporal bones on radiographic examination which do not fit into Wittmaack's scheme. Mayer believes that different qualities of mucosa, reacting differently to inflammation, result in different patterns of pneumatization.

Pneumatization is probably dependent on a combination of factors, mainly, (1) the vigor of the proliferating epithelium and its forerunner, the embryonal connective tissue; (2) freedom from middle ear irritation by foreign bodies and hemorrhage, incidental to the birth process; (3) anatomic predisposition; (4) free communication with the external air, and (5) a healthy mucosa, capable of resisting infection or of recovering from infection without severe damage and degeneration. Moreover, failure of pneumatization (*i.e.*,

inhibition) and arrest or disturbance of pneumatization may be assumed to result from an alteration in one or more of these factors. Many of Wittmaack's contentions are reasonable from a clinical point of view. Frequently one finds that on careful subsequent inquiry for an etiologic factor, a history of infantile otitis is elicited after it had been originally denied. Infantile otitis often remains unnoticed; contagion otitis is often unnoticed and untreated, and ear suppuration early in life is often allowed to exist for unduly long periods without surgical aid. These undoubtedly disturb the process of pneumatization sufficiently to manifest defective development in later life.

With the exception of the classical works of Cheatle and Wittmaack, little reference is made to the period of development between one and six years of age. The importance of this period is emphasized by the writer in his following contentions which are based on radiographic evidence.

(1) Pneumatization of the mastoid is initiated in infancy and completed in early childhood, all within the first six years of life. At the age of six, the full complement of cells is present; thereafter, there is no perceptible increase in number but the cells do become more distinct by virtue of continued calcification of their walls.

(2) Variations of pneumatization resulting from inhibition and arrest of pneumatization, when they occur, are invariably demonstrable as a fixed mastoid pattern by the end of the sixth year of life.

(3) By the end of the sixth year, the growth of the mastoid has attained adult proportions, but at no time does the number of cells determine the size of the mastoid.

(4) Alteration of the fixed mastoid pattern can occur after the sixth year, only as the result of subsequent infection, trauma, or disturbances of bone metabolism.

TABLE I.—MASTOIDS

Group I Normal Development	Group II Defective Development
Type 1. The Infant Mastoid (birth to two years)	Type 1. The Undeveloped Mastoid (after two years) (*a*) Cellular (*b*) Diploic (*c*) Sclerotic
Type 2. The Transitional Mastoid (two to five years)	
Type 3. The Fully Developed Mastoid (at and after six years)	Type 2. The Partially Developed Mastoid (after six years) (*a*) Squamal tract (*b*) Antral tract (*c*) Tympano-tip tract (*ab*) Squamal and antral (*ac*) Squamal and tip (*bc*) Antral and tip

ANATOMIC CLASSIFICATION

From the foregoing review of the theories of the process of pneumatization, it becomes evident that the most informative classification of mastoids would be one that is based on pneumatization. In a previous communication (11), the writer stated that mastoids may be classified according to their growth and development, development being synonymous with pneumatization. Growth is not as important as development, clinically, and whereas all mastoids grow, some mastoids do not develop at all, which others present marked and distinctive variations in development. Therefore, the state of development for age, and its variations, judged radiographically, constitute desirable criteria for grouping and typing all mastoids.

Thus, mastoids are divided into two groups, the first consisting of those which evidence normal development for their age, and the second of those which evidence defection of development, as shown in Table I.

In this classification, the so-called diploic and sclerotic mastoids are not recognized

as entities. The petromastoid bone which gives rise to the mastoid process is diploic and remains so if there is inhibition of pneumatization; with arrest of pneumatization, that part which was not invaded by air cells remains diploic (normal skull bone). Sclerosis, on the other hand, results from a break in the balance between local blood supply and local calcium, most probably of pathologic origin. Thus it may occur anywhere in any except the infant type of mastoid.

THE PERI-ANTRAL TRIANGLE

For judging development whereby mastoids may be grouped and typed, the peri-antral triangle is the landmark of prime importance. It is defined on a radiograph

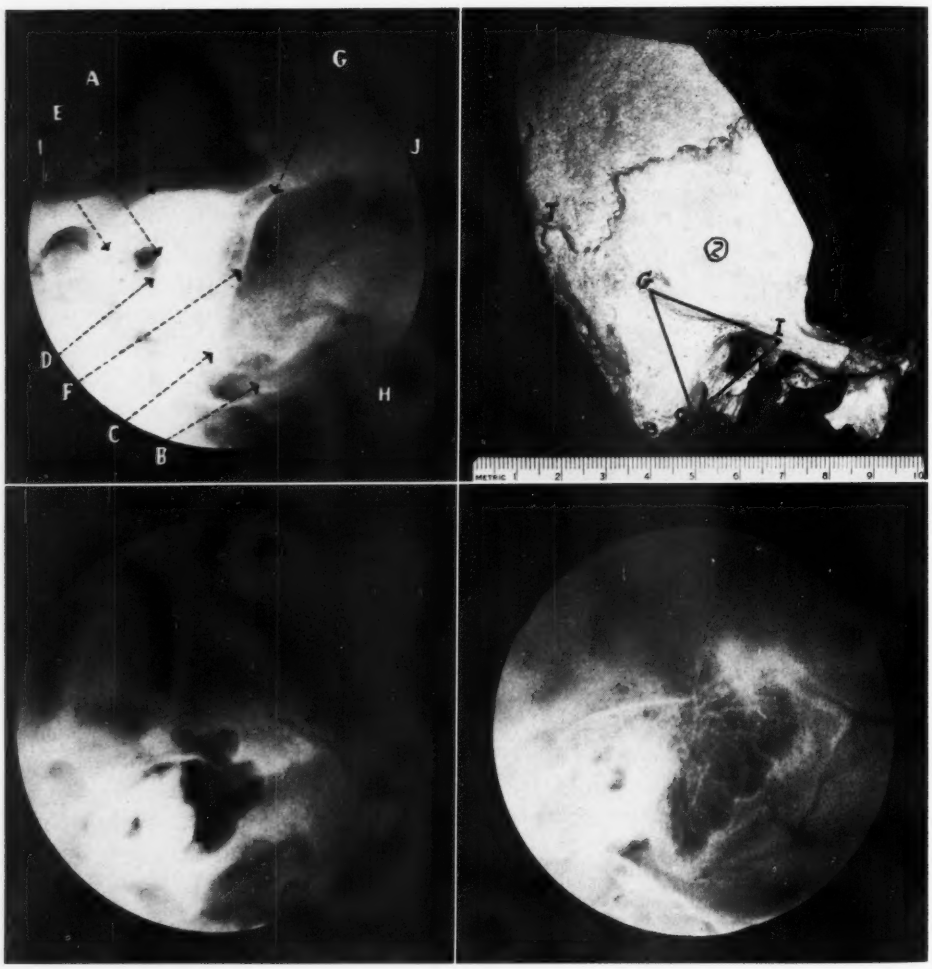


Fig. 1 (*upper left*). The peri-antral triangle (radiograph of an undeveloped mastoid). *A*, arcuate eminence or tegmen line; *B*, center of mastoid tip; *C*, tympano-mastoid fissure (lower angle of triangle); *D*, floor of external meatus; *E*, posterior wall of external meatus; *F*, sinus plate (anterior lip of groove); *G*, parietal notch; *H*, emissary vein at posterior border of mastoid; *I*, post-glenoid process, and *J*, asterion.

Fig. 2 (*upper right*). The peri-antral triangle (external view of the mastoid). *I*, post-glenoid process; *G*, parietal notch; *C*, tympano-mastoid fissure; *B*, center of mastoid tip, and *J*, asterion.

Fig. 3 (*lower left*). The transitional mastoid (age, three years). Note expanding cells pointing in three directions.

Fig. 4 (*lower right*). Transitional mastoid (age, four years).

(Fig. 1) as being almost equilateral, and is bounded by the line of the tegmen above, posteriorly by the groove for the sigmoid sinus, and anteriorly by a line joining the other two. Concisely, the superior line runs from the post-glenoid process backward and almost horizontally to the parietal notch; the posterior line runs from the parietal notch diagonally forward and downward, corresponding to the anterior lip of the groove for the sigmoid sinus. It terminates at the lowermost point of the tympanomastoid suture; the anterior line completes the triangle, running through the anterior wall of the canal. The same lines obtain on the external view of a temporal bone (Fig. 2).

The triangle is roughly the equivalent of Cheatle's "outer antral wall," corresponding to the squamozygomatic portion of the squamous part of the temporal bone. On a radiograph, the triangle encompasses the shadows of the antrum, the peri-antral cells, and the labyrinth, and corresponds in outline to the base of the petrous pyramid. Before the age of two, the triangle may or may not be visualized clearly; it begins to appear sharp between the ages of 15 and 20 months, and is quite distinct at two years. Therefore, development is judged only after two years, at which time, under normal conditions, cells begin to migrate beyond the borders of the triangle; however, when development is inhibited, no cells appear outside the triangle.

The peri-antral triangle is so basic a landmark that it is visualized very clearly on radiographs taken after simple and radical mastoidectomy and even after numerous revision operations on the mastoid.

GROUP I.—NORMAL DEVELOPMENT[2]

Type 1. *The Infant Mastoid.*—This is the normal mastoid of the first two years of life. At birth, it possesses the shadows of the tympanic ring and labyrinth, which structures are already calcified. From six to twelve months of age, there is an increasing definition of the antrum and of a few surrounding small cells, which have very fine lines; these are seen running criss-cross in all directions, between the age of 15 and 18 months. At this time, the tegmen line is already sharp, while the posterior line of the triangle is first becoming sharp. At 24 months of age, the triangle is sufficiently calcified to permit visualization. There may be a number of small white (bone) lines extending upward toward the squama and a number radiating backward across the sinus groove. In some mastoids the squamal lines appear earlier and are more prominent. The bone over (*i.e.*, external to) and posterior to the sinus groove is uniformly smooth in texture, extending to the parietal and occipital suture lines. Occasionally, on light films, the groove for the emissary vein is visible.

Type 2. *The Transitional Mastoid.*—This is the mastoid which is found between the ages of two and five, a period that marks the transition in growth and development from the infant type to the fully developed type.

During this period, there is slow expansion of cells (Fig. 3), migration toward the periphery, and concomitant multiplication of cells and increase in the size of the mastoid process (Fig. 4). The migrating cells are characterized by fine, elongated, thinly calcified lines, which exhibit a directional tendency. They offer poor radiographic contrast as compared with cells of the adult type, because they are calcified to a lesser degree and because the mastoid process is not so deep as the adult type. For the same reasons, interpretation of pathology in this type of mastoid is quite liable to error.

During the third and fourth years of life, the long fine lines of migrating cells are spaced regularly and irregularly, radiating backward, upward, and downward from the antral area as a center. From these lines, short, thin, spike-like projections appear at irregular intervals. They probably are the "splinters" to which Wittmaack refers. The projections gradu-

[2] Radiographic appearance and measurements apply to films made at 30 inches, in the 15 × 15 degree position, without diaphragm.

ally blend to envelop numerous small areas which assume the appearance of small rounded air cells. There are many such small cells within the peri-antral triangle, but, posterior to the triangle, they do not become numerous and distinct until about the fifth year. In many mastoids the spike-like projections do not appear in the peripheral zone, permitting the expanded cells to remain large (Fig. 5).

As pneumatization spreads beyond the borders of the peri-antral triangle, cell formation takes place in three directional groups (Fig. 6) as follows:

(1) *The Squamal Tract.*—Cell lines extend upward from the antral area, perpendicular to the tegmen line which they cross to invade the squama. The more anterior lines may turn forward to invade the zygomatic process (Fig. 7), occasionally to a marked extent; the posterior cells are limited by the parietal notch.

(2) *The Antral Tract.*—Cell lines course backward from the antral area to cover the sinus groove and to travel toward the parietal and occipital sutures. Some lines radiate upward to cover the knee of the sinus, travelling up to and in front of the parietal notch while others course below and past the parietal notch, but they never cross it and never invade the parietal bone. Other lines flow downward to reach the tip, truly resembling a waterfall as they leave the antral area. Non-directional lines represent cells travelling toward the cortex, medio-laterally.

(3) *The Tympano-tip Tract.*—Cell lines, rather hidden, pass downward and slightly backward from the middle ear, in front of and alongside the anterior lip of the sinus groove, to and into the tip. They often turn backward and upward to follow the outline of the tip toward the emissary vein. This tract is mentioned by Cheatle

TABLE II.—MEASUREMENTS OF MASTOID GROWTH AND DEVELOPMENT

Group and Type	Age	A-B	A-C	A-D	D-B	E-F	E-G	E-H	I-J	U-V	W-Y	X-Z
Normal Development												
Group I Type 1 Infant Mastoid	at birth	15		13	10			25	45			
	6–12 mos.	15–20		12	10–12			25	50	20	20	15
	18 mos.	18–20	18–20	14	15	10	15	25–30		25	25	20
	2 yrs.	20–25	20	15	16	10	20	25–30	55			
Type 2 Transitional Mastoids	$2^1/_2$ to 3 yrs.	22–25	20–25	15	18–20	10–15	20	25–35		25	30	25
	$3^1/_2$ to 4 yrs.	25–30	20–30	16	20–25	15	25	25–35		35	35	35
	5 yrs.	30–32	25–30	15–20	22–26	15	25	30–35	60	45	45	35
Type 3 Fully Developed (Bone Specimens—Adult)	6 yrs.	35–40	25–30	15–20	25–30	15	25	35	60–65	45	45	35
	7–60 yrs.	35–40	25–30	15–20	25–30	15	25	35–40	60–65	40–50	45	35
		40	30	20	26	15	26	38	55			
Defective Development												
Group II Type 1 Undeveloped Mastoids (Bone Specimens—Adult)	5 yrs.	30	25	15	20	10	20	35				
	13 yrs.	30	30	15	20	13	25	35	50–60			
	adult	35	30	15	20	12–14	20–25	35–40	50–60			
		30–32	25	20	20	15	25	28	50			
Type 2 (*a*) Partially Developed (*b*) Mastoids (*c*) Age 7–65 yrs.	Squamal	35–40	25–30	15	25	15	25	30–40	50–60	40	25	25
	Antral	35–40	25–30	15	25	15	20–30	30–40	50–60	30–50	20–35	25–30
	Tip	30–35	25–30	15	25	15	20–30	30–40	50–60	10–20	10–25	20–35
	a and *b*	35–40	25–30	15	25–30	15	30–35	30–40	50–60	55	50	45
	a and *c*	35–40	25–30	15	25	15	30–35	30–40	50–60	50	40	35
	b and *c*	35	25–30	15	25	15	30–35	30–40	50–60	40	30	35

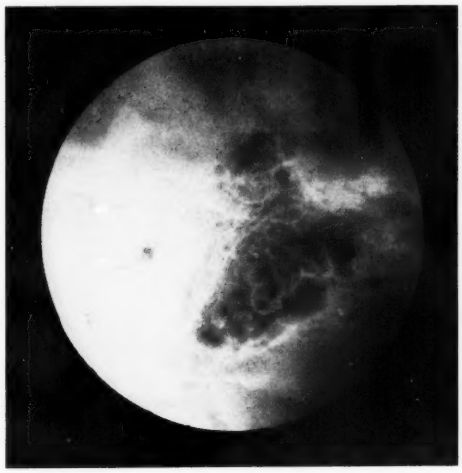
Measurements are average and are expressed in millimeters. They apply to films made at 30 inches in the 15 and 15 degree position, without diaphragm. Radiographic measurements of the living mastoid and of bone specimens coincide. The antrum at birth measures 10 × 10 mm. Cells in squama extend to from 10 to 20 mm. above the tegmen line. Over-all cell mass averages in adult 40 × 45 mm., and rarely exceeds 50 × 55 mm. In one mastoid at age five, the over-all cell mass measured 55 mm. from above downward and 65 mm. from before backward, including zygomatic cells. *A-B*, Arcuate eminence (highest point on tegmen line) to center of tip; *A-C*, Arcuate eminence to lower angle of peri-antral triangle; *A-D*, Arcuate eminence to floor of meatus; *D-B*, Floor of canal to center of tip; *E-F*, Posterior canal wall to anterior lip of sinus groove; *E-G*, Posterior canal wall to posterior angle of triangle; *E-H*, Posterior canal wall to posterior border of mastoid at emissary vein; *I-J*, Post-glenoid process to asterion; *U-V*, Uppermost cell to lowermost cell; *W-Y*, Most anterior cell to most posterior cell, and *X-Z*, Posterior canal wall to most posterior cell.

as coming into relation to the canal for the facial nerve; it is described more specifically by Wittmaack, and has been demonstrated more recently by Almour (12). When cell formation is proceeding evenly throughout the mastoid, the tympano-tip tract is not perceptible as such, but when there is failure of the antral tract to invade the tip and the tip tract is developed, it then becomes apparent. This tract is responsible for the formation of a broad tip in the fully developed mastoid. In its absence, the tip is narrow or pointed.

Vigorous pneumatization is evidenced by the simultaneous development of cells in all three tracts at a uniform rate, all groups merging and blending to form a heterogeneous mass of cells. No one group of cells or pathway of pneumatization is outstanding; the course of the sigmoid sinus gradually becomes obscured; there is an orderly convexity of the periphery which is broken only by the indentation produced by the parietal notch. The superior and posterior lines of the peri-antral triangle are almost hidden by cells. The mastoid is about to attain a state of full development.

Type 3. *The Fully Developed Mastoid.*—This mastoid no longer shows signs of transition. It possesses a full complement of cells, which extends close to, if not up to, the posterior border, into the squama, into the tip, and sometimes into the zygoma. The cell walls are calcified, the cells are superimposed except at the extreme periphery, and the mastoid process is deep. Therefore there is good radiographic contrast. The course of the sigmoid sinus and the superior and posterior lines of the peri-antral triangle are barely distinguishable. The emissary vein may or may not be visible.

The cells of the *squamal tract* are usually of medium size, round or oblong, and placed in shallow formation; cell lines run upward, meeting to form an inverted *U*. In the zygoma, the cell lines run forward and slightly upward, the open end of the *U* facing the antral area. The cells of the *antral tract* are multishaped, small or large and somewhat elongated peripherally. The open end of the *U* faces the antrum, and represents the opening by which the cell was "blown"; in the antral tract, the *U*-shaped closure of the cell is toward the posterior border, except in cases in which cells are running toward the external cortex of the mastoid, in which case there is no *U* formation, the cells appearing cir-



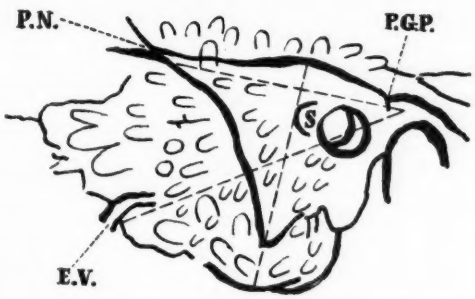


Fig. 5 (*above*). Transitional mastoid (age, five and one-half years).

Fig. 6 (*below*). Schema of pathways of pneumatization. The squamal group appears above a line drawn between the parietal notch (*P.N.*) and the post-glenoid process (*P.G.P.*). The antral group appears between two lines extending backward from the *P.G.P.* as a center, the upper running to the parietal notch, the lower to the emissary vein (*E.V.*). Antral cells appear posterior to a line drawn from the arcuate eminence to the center of the tip, which line runs through the shadow of the external semicircular canal (*S*). The tympano-tip tract group appears below the middle ear on the anterior surface of the mastoid, anterior to the last mentioned line, until the cells reach the tip, whence they curve backward and upward.

cular. The *tympano-tip tract* cells are large, as a rule, the lines pointing downward, thence backward and upward from the center of the tip. The *U*-shaped closure is found facing the antrum in some tip cells, thus differentiating them from those of the antral tract.

The fully developed mastoid may be found as early as at the age of five and at any time thereafter. Very rarely does its appearance change after the sixth year.

GROUP II.—DEFECTIVE DEVELOPMENT

Type 1. *The Undeveloped Mastoid.*—Any mastoid which fails to evidence air cells beyond the borders of the peri-antral triangle after two years is undeveloped. Such a mastoid shows evidence of growth but not of development. It resembles the infant mastoid in outline, but is larger in size. It is often referred to as an "infantile mastoid," a term that is confusing because it places the normal mastoid of infancy in

Fig. 7 (*upper left*). Extensive pneumatization of the squama and zygoma.
Fig. 8-*A* (*upper right*). Fully developed mastoid.
Fig. 8-*B* (*lower left*). Partially developed mastoid. Arrested pneumatization produces a break in the peripheral convexity, giving a clear impression, in this film, of the three groups of cells.
Fig. 9 (*lower right*). Partially developed mastoid, squamal group (age, three and one-half years). The antral and tip groups are definitely arrested.

the same category with an older mastoid which has failed to pneumatize and is, therefore, not normal.

The undeveloped mastoid is characterized by a prominent peri-antral triangle and a sharply defined sinus groove. It is subclassified according to the content and texture of its peri-antral triangle, as being: (*a*) cellular—the triangle is filled more or less with cells; (*b*) diploic—the triangle has few or no cells and manifests a texture of diploic bone; semicircular canals may be identified, and (*c*) sclerotic—the triangle is a dense mass of bone, so opaque that identification of any structure within the triangle is difficult, if not impossible.

Failure of development is found bilaterally more often than unilaterally. Otitis of infancy is predominantly a bilateral lesion. Associating these two facts, one may conclude that infection or other disturbance in the middle ear, in the first two years of life, is the cause of non-development. Speculatively, one may assume that damage to the mucosa, produced during intra-uterine life or at birth, results in the diploic type of undeveloped mastoid, whereas damage to the mucosa during the first year of life results in the cellular type of undeveloped mastoid. The sclerotic undeveloped mastoid has never been identified by the writer before the age of five years and seems always associated with recurrent or chronic suppuration of the ear.

Sclerosis in mastoids under ten years of age is an infrequent radiographic finding, anatomic findings to the contrary notwithstanding. The writer has exhibited a comparison of four pairs of mastoids of patients, each 13 years of age. Two of the patients had been under his care since early infancy for their original bilateral otitic suppuration and for recurrent otitic infections; the other two had never had suppurative otitis, but were examined radiographically, one because of recent trauma, the other because of defective hearing. The four pairs of mastoids are undeveloped and have a remarkably similar radiographic appearance. The authentic record of suppuration in two of these patients coincides with the conception of otitis of infancy as the cause of non-development of the mastoids.

It is reasonable to assume that non-development of the mastoids in the other two patients resulted from fetal or infantile otitis, despite the history of no recognized suppuration or recurrent infection. In the

TABLE III.—MEASUREMENTS OF PERI-ANTRAL TRIANGLE

(Averaged and Expressed in Millimeters)

Type of Mastoid	Age	I-G	G-C	C-I
Normal Development	1 yr.	25	25	20
" "	2 yrs.	30	25	25
" "	3 yrs.	30	30	30
" "	4 yrs.	35	35	30
" "	5 yrs.	35–40	35	35
Undeveloped	6 yrs.	30	25	25
"	9 yrs.	30	30	25
"	12 yrs.	35	35	30
"	adult	35	30–35	30
Partial Development				
(*a*) Squamal	4 yrs.	30	25	25
"	adult	30	30	30
(*b*) Antral	"	35	25	25
(*c*) Tip	"	35	35	35
(*ab*) Squamal and antral	"	35	30	30
(*ac*) Squamal and tip	"	40	30	35
(*bc*) Antral and tip	"	30	30	30

I-G, Post-glenoid process to parietal notch; *G-C*, Parietal notch to lower angle of triangle, and *C-I*, Lower angle to post-glenoid process.

traumatic case, both mastoids are alike, cellular—undeveloped; hearing is normal. In the other non-suppurative case, there is a history of measles and scarlet fever; the drums are dull; hearing is impaired in both ears. Both mastoids show a marked tendency to sclerosis of the triangle; no cells are visible. In both cases of recurrent infection, the right ear had been infected more often than the left and both right mastoids manifested a greater tendency toward sclerosis of the triangle.

Radiographic examination of adult mastoids, with histories of recurrent suppurative otitis or chronic otitis in childhood, usually reveals a sclerosis of ivory density in the triangle, with or without a sclerosis of the mastoid tip and along the posterior border of the mastoid. It is the writer's opinion that the evolution of sclerosis in the mastoid is a very gradual, time-consuming process; that sclerosis is a graded deposit of calcium salts resulting from a diminution in local blood supply and an excess of local calcium, following inflammatory irritation. Therefore, sclerosis is considered the result of a defense reaction to past disease and not evidence of a recent lesion. The so-called "sclerotic mastoid" is not considered a type of mastoid nor an entity, for sclerosis may occur in individual cells, in discrete areas, and throughout the mastoid, often superimposed on diploic bone.

Type 2. *The Partially Developed Mastoid.*—The mastoid process may develop rapidly or slowly, may contain many or few cells, and may attain a relatively large or small size. It develops into different shapes, becoming tall or short, broad or narrow, deep or shallow. The characteristic individuality of each mastoid results from a combination of developmental features, in which pneumatization plays an important part.

With vigorous pneumatization, there is usually full development of the mastoid (Fig. 8-*A*). When pneumatization fails to occur, there remains an undeveloped mastoid. After pneumatization has already begun and has extended beyond the borders of the peri-antral triangle, it is still subject to arrest. It may be halted generally at any stage of its progress (Fig. 8-*B*). On the other hand, it is possible for one or two of the three directional groups of cells to be arrested, while the other one or two continue to develop, together or individually, at the same or at different rates of speed and to the same or different extents.

Arrest of pneumatization occurs between the ages of two and five years, and results in a partially developed mastoid, the cell pattern of which is fixed for life at the age of six years. It is identified by a break in the convexity of the peripheral outline of the cell pattern, or by an extension of cells solely in one direction beyond the triangle. Thus, cells may be found—

(*a*) Solely in the squamal tract, outside and above the triangle (Fig. 9).

(*b*) Solely in the antral tract, running backward below the tegmen and above the tip, across the sinus groove (Fig. 10).

(*c*) Solely in the tip, emerging from the lower angle of the triangle and occupying part or the whole of the tip (Fig. 11).

(*ab*) Invading the squama and coursing over the sinus groove, even reaching the posterior border of the mastoid, but the tip is narrow or pointed and contains a few antral tract cells, else it is rounded and diploic. This picture probably results from an infection of the middle ear which alters the mucosa that proliferates into the tympano-tip tract without affecting the antral mucosa (Fig. 12-*A*). Another possibility is that the middle ear in question does not possess the anatomic pathway which gives passage to the tympano-tip tract of cells (Fig. 12-*B*).

(*ac*) Invading the squama and the tip; the knee of the sinus groove is exposed to view, no cells covering it. This void over the sinus knee is occasionally misinterpreted as necrosis in that area (Fig. 11).

(*bc*) Filling the tip and rounding out the whole mastoid up to the line of the tegmen. The squama is void of cells. This mastoid closely resembles the normal, fully developed one.

ROENTGEN, CLINICAL, AND SURGICAL CORRELATIONS TO THE PATTERNS OF PNEUMATIZATION

A. Roentgen Signs in Acute Infection.—The infant mastoid will evidence loss of aeration in the antrum. At no time does the radiographic appearance of the infant mastoid speak for or against surgical intervention.

The transitional mastoid will evidence loss of aeration and decalcification. The latter must not be confused with destruction of bone. Loss of definition of the fine lines of migrating cells and increasing opacity of the cell mass indicate necrosis.

The fully developed mastoid will manifest loss of aeration, decalcification, and increased visibility of deeper structures, namely, the sinus groove and the semicircular canals. Destruction is evidenced by loss of continuity of cell lines and coalescence of cells with increasing opacity of the

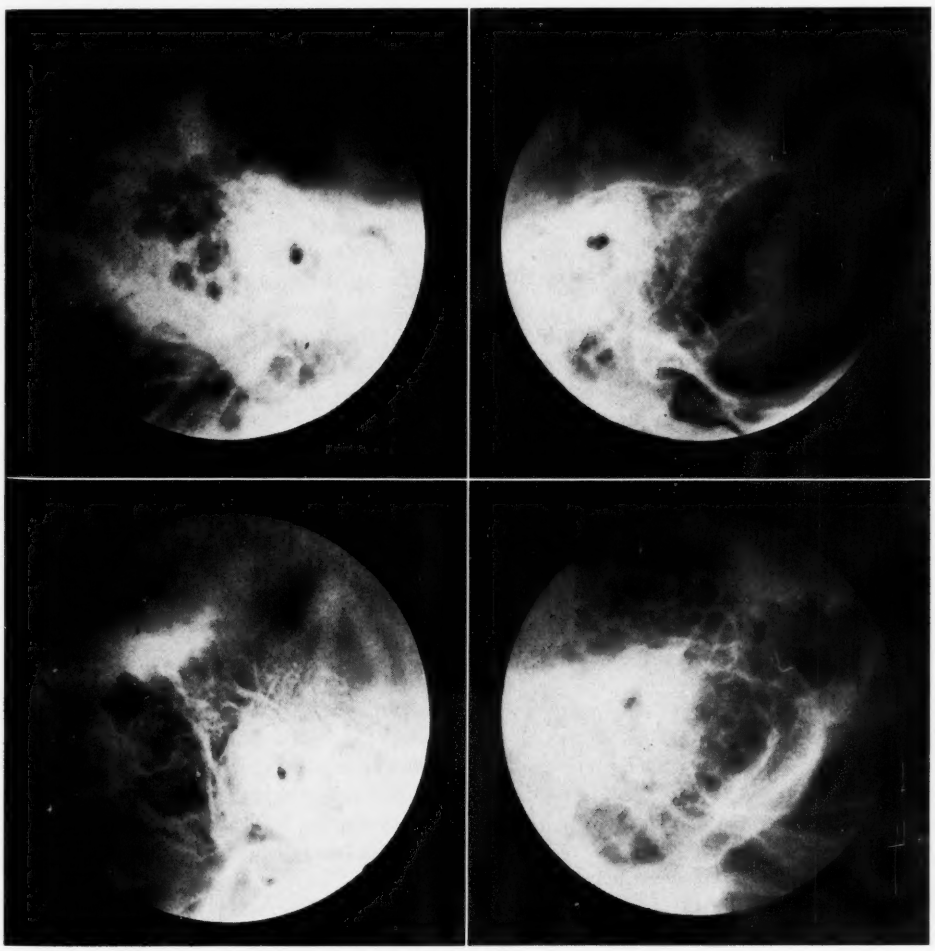


Fig. 10 (*upper left*). Partially developed mastoid, antral group (adult).
Fig. 11 (*upper right*). Partially developed mastoid, tympano-tip tract (adult).
Fig. 12-*A* (*lower left*). Partially developed mastoid, tip tract completely arrested, squamal group well developed, antral group arrested in part (age, seven and one-half years). History of suppurative otitis media.
Fig. 12-*B* (*lower right*). Partially developed mastoid; the squamal and antral groups are well developed. The tip group is missing, as evidenced by a diploic tip (adult).

cell mass. This picture is diagnostic of a surgical mastoid.

The cellular undeveloped mastoid will lose aeration in the triangle. The diploic and sclerotic undeveloped mastoids will show no change at all.

The partially developed mastoid will evidence changes in proportion to the degree of its cellularity. The squamal tract, being shallow, will lose cell outlines sooner than it will evidence changes in aeration, when necrosis takes place.

The antral tract will act like the fully developed mastoid. The tip tract will lose aeration and cell outlines, the tip area becoming opaque.

The petrous pyramids, on base films, nearly always appear alike and symmetrical, though the pneumatization of the two mastoids differs widely. Recurrent mastoid infection and several revision operations for such infection do not, as a rule, produce any perceptible change in the appearance of the pyramids.

B. Symptoms in Acute Mastoiditis.—Headache is a symptom common to all types of mastoids, except the infant.

Temperature elevation may or may not be present in any type of mastoid.

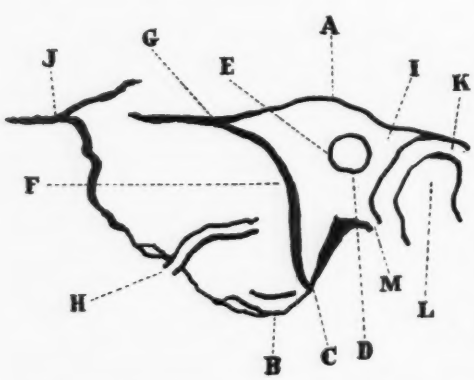


Fig. 13. Diagram of mastoid radiograph, showing points from which measurements in Tables II and III are made, and localizing other landmarks. *A*, arcuate eminence; *B*, center of tip; *C*, lower angle of peri-antral triangle; *D*, floor of canal (meatus); *E*, posterior wall of canal (meatus); *F*, sinus plate (anterior lip of groove); *G*, parietal notch; *H*, emissary vein at posterior border of mastoid; *I*, post-glenoid process; *J*, asterion; *K*, glenoid cavity or fossa; *L*, condyle of mandible, and *M*, styloid process.

Mastoid pain, subjectively, may be present in any type; but objectively, elicited as tenderness, it is greatest in fully developed and transitional mastoids. It is elicited at the posterior border when the structure of the mastoid permits filtration of the toxin and/or micro-organism from the mastoid into the highly sensitive periosteum. Under these conditions, it is not found in undeveloped mastoids and it is not a frequent finding in partially developed mastoids, in which cell formation was arrested close to the peri-antral triangle.

Early and persistent tip tenderness is a sign of a well-developed tympano-tip tract.

Sagging of the canal is dependent on the presence of cells in the region of the posterior and superior canal walls, and results from periosteal infiltration secondary to infection of those cells: conversely, no cells, no sagging.

Discharge is purely a middle ear affair. The quantity of discharge is not proportionate to the cellularity of the mastoid nor to the severity of the infection. In fact, there may be no discharge in the presence of extensive destruction of the mastoid.

C. Surgical Correlations.—Infant mastoiditis is antritis plus osteitis of the "mastoid mass" of diploic bone. The area of necrosis therefore extends beyond the limited pneumatic area seen on the film.

Suppuration in the squamozygomatic cells (zygomatic mastoiditis) may perforate above and anterior to Macewen's triangle; suppuration in the antral tract may perforate in Macewen's triangle or just below and behind it; suppuration in the tip tract leads to empyema of the tip, Bezold perforation, and suboccipital and digastric fossa abscess. This tract is also responsible for the occasional involvement of the facial nerve.

Epidural abscess is often secondary to suppuration in the squamal tract. Perisinus abscess is secondary to suppuration in the antral tract. Sinus thrombosis will occur in any type of mastoid. A spreading infection of the middle ear finds no harbor in an undeveloped mastoid, and, therefore,

leads to intracranial infection, which term includes labyrinthitis, petrositis, and sinus phlebitis and thrombosis, sigmoid and bulbar. This statement does not imply that such complications do not and cannot occur in other types of mastoids, but it does imply that the classical symptoms of mastoiditis do not occur in an undeveloped mastoid. Early and wide exposure of the pathways of extension of infection is necessary in such cases as soon as signs of intracranial involvement are noted.

The appearance of the mastoid cortex on surgical exposure gives no clue to the state or pattern of pneumatization. These can be determined only by x-ray examination.

D. Regarding Hearing.—The degree of pneumatization, failure and arrest of pneumatization, are not indicative of the functional capabilities of the ear as a sense organ. There may be hearing defects in the presence of normal pneumatization, and there may be normal hearing in the presence of defective pneumatization. However, the most common finding in cases of defective hearing is defective pneumatization with sclerosis.

SUMMARY

Roentgen study of a large number of films of the mastoid reveals evidence of distinct types of mastoids. These types have distinct variations of pneumatization for a given age. The variations fall into separate classes, according to the pathways of development. These pathways, which are demonstrable radiographically, correspond closely to the pathways of pneumatization found on histologic and anatomic examination. The types of mastoids and the variations in pneumatization are sufficiently distinct radiographically to serve as a basis for a definite classification. The practical application of this roentgen-anatomic classification is demonstrated by the correlation of variations in pneumatization to variations in symptoms and in surgical indication.

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CONCRETE AS A PROTECTIVE MATERIAL AGAINST HIGH VOLTAGE X-RAYS[1,2]

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ABSTRACT

A description is given of relative x-ray transmission measurements on a group of especially prepared concrete specimens and commercial building blocks selected to sample the concrete mixes and cover the range of concrete densities in common use. It was found that the lead equivalent of any concrete was an increasing function of its mass per unit area and independent of the nature of the mix. Relations between lead equivalence, density, mass, and thickness are given, from which the thickness of concrete necessary for adequate protection can be calculated for any voltage in the voltage interval 200 to 400 kv.

I.—INTRODUCTION

WITHIN the past few years the highest excitation potentials commonly used in x-ray therapy have been raised considerably above the 200-kv. limit of 15 years ago; 400-kv. equipment is now commercially available, and there are numerous x-ray generators of various types operating at potentials between 400 and 1,000 kv. There has been a corresponding extension in the application of x-rays to the inspection of metals, and in the use of x-radiation as a scientific tool in the physical laboratory. With this trend, the need for adequate protection of personnel against very penetrating radiation has become more urgent than ever.

Lead has been the most commonly used protective material; both in metallic form as sheet lead and lead shot and in combination with other materials, as in lead-rubber and x-ray protective glass. For the most penetrating x-radiation available a few years ago, no other protective material compared at all favorably with lead except barium, and the usefulness of the latter was limited by practical difficulties in making a homogeneous barrier. For this reason, the Advisory Committee on X-ray and Radium Protection has made all recommendations for x-ray protection (1) in terms of lead and has recommended that the effectiveness of all other materials be measured by their lead equivalents. In Table I are given the recommended lead barriers for direct x-radiation excited by potentials up to 600 kv.—the present voltage limit of the recommendations. The recommendations of the committee are given in columns 1 and 2 of Table I. Column 3 has been added to show the approximate weight per square foot of lead barrier recommended in column 2. The weight of the required barrier is seen to increase so rapidly with increasing excitation potential that above 200 kv. the cost of lead for such a barrier becomes very high and the problem of supporting the required lead mass becomes serious.

TABLE I.—MASS OF LEAD BARRIER FOR ADEQUATE PROTECTION

Potential	Recommended Minimum Equivalent Lead Thickness	Weight of Barrier[1]
1	2	3
kv.	mm.	lb./ft.(1)
75	1.0	2.4
100	1.5	3.5
150	2.5	5.9
175	3.0	7.1
200	4.0	9.5
225	5.0	14
300	9.0	21
400	15.0	35
500	22.0	52
600	34.0	80

[1]Approximate.

One possible solution is to make the protective barrier of a material which is self-supporting. Concrete suggests itself

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Preliminary report presented at the Fifth International Congress of Radiology, in Chicago, September, 1937.

at once. In any case, however, for radiation of a given quality, the mass of an adequate concrete barrier will always be greater than that of a corresponding lead barrier; but since the concrete is self-supporting and relatively inexpensive, this increase in weight is not particularly objectionable except in the case of installations in existing buildings unable to withstand the additional loading.

Such data (2) as have been published on the lead equivalence of concrete are old and are confined to x-ray excitation potentials not exceeding 200 kv. It is the purpose of the present paper to give the results of measurements on a series of concrete samples and commercial building blocks for x-ray potentials ranging from 200 to 400 kv.

II.—METHOD

The lead equivalent of each concrete sample was obtained by direct comparison with sheet lead, 99.9 per cent pure, meeting Federal specifications for grade *A* lead. The method used is essentially that previously described for determining the lead equivalence of x-ray glass (3). The experimental arrangement is shown in Figure 1; for complete constructional details of the x-ray tube, ionization chamber, and current-measuring system, the original paper describing this apparatus should be consulted (4).

As is shown in Figure 1, the beam of radiation, *bb'*, emerges from the tube at an angle of 90 degrees to the tube axis, and after passing through the concrete test cylinder shown, enters the ionization chamber, *c*. The cross-section of the beam is limited by the four diaphragms shown. The resulting ionization current, after amplification, is measured by direct deflection of a high sensitivity galvanometer in the output of the amplifier. When measuring radiation through heavy protective barriers the residual ionization current due to scattering, radio-active contamination, and cosmic radiation, is a considerable fraction of the total current measured. For such measurements requiring the highest sensitivity, a rate-of-drift method is used in order to get the benefit of a time average for this background radiation; this average remains fairly constant and affects alike the measurements of the standard filters and test specimens, so that, as a rule, no zero correction in the ionization readings is necessary.

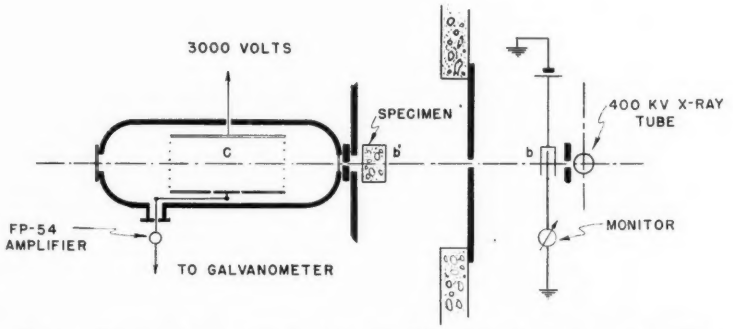

Fig. 1. Diagram of apparatus used in determining the lead equivalent of concrete.

III.—DESCRIPTION OF CONCRETE

The concrete specimens, on which tests were made, were selected so as to cover adequately the types of mixes and range of densities most commonly used. These specimens fall into two classes: (*a*) the first consists of a group of especially prepared

TABLE II.—PREPARED CONCRETE SPECIMENS

Specimen	Proportions (cement to sand to gravel)	Approximate Dimensions		Density of Specimens at 24 Hours		C/W[a] Ratio	Consistency, Expressed as Approximate Slump
		Height	Diameter				
Gravel Concrete							
		Inches	Inches	lb./ft.(2)	g./cm.(2)		Inches
G1	1:2.2:3.8	$4^1/_4$	6.0	148	2.3_7	1.60	6
G2	1:2.2:3.8	$6^1/_8$	6.0	146	2.3_4	1.60	6
G3	1:2.2:3.8	$8^1/_2$	8.0	147	2.36	1.60	6
G4	1:2.2:3.8	$4^1/_4$	6.0	152	2.47	1.75	3
G5	1:2.2:3.8	$6^1/_8$	6.0	147	2.36	1.75	3
G6	1:2.2:3.8	$8^1/_4$	8.0	150	2.40	1.75	3
G7	1:2.2:3.8	$4^5/_{16}$	6.0	150	2.40	1.90	1
G8	1:2.2:3.8	$6^1/_2$	6.0	150	2.40	1.90	1
G9	1:2.2:3.8	$8^1/_{16}$	8.0	148	2.37	1.90	1
Limestone Concrete							
L1	1:3.6:2.4	$4^1/_8$	6.0	144	2.31	1.75	3
L2	1:3.6:2.4	$6^3/_8$	6.0	147	2.36	1.75	3
L3	1:3.6:2.4	$8^1/_{16}$	8.0	144	2.31	1.75	3
N	([b])	$4^1/_{16}$	6.0	132	2.1_2	4.17	([c])
NN	([b])	$4^1/_{16}$	6.0	132	2.1_2	4.17	([c])

[a]Cement-water ratio. [b]Neat cement. [c]Normal consistency.

test specimens;[3] (*b*) the second consists of a group of solid building blocks which were obtained on the market. Tables II and III give data on all specimens.

1. *Prepared Specimens.*—Three types of specimens were prepared. Specimens *N* and *NN* were made of neat cement of normal consistency (24 per cent of water). Specimens *G* were nominal 1:2:4 mixes, the exact cement-sand-gravel proportions being 1:2.2:3.8, respectively, by weight. Potomac River sand (quartz), fineness modulus 3.1, was used as fine aggregate. Potomac River gravel (quartz), size No. 4 to $1^1/_2$ inches, was used as coarse aggregate in mix *G*, and Potomac River sand and West Virginia limestone in mix *L*. In mix *L* the sand–coarse-aggregate ratio was adjusted to give maximum density for the mix with the size limestone (No. 4 to $^3/_8$ in.) that was available. The proportions of mix *L* were 1:3.6:2.4.

The specimens were cylinders six or eight inches in diameter and approximately four, six, or eight inches in thickness: the thickness in all cases was not more than the nominal diameter. They were kept in molds for 24 hours, then stored in a moist room for three weeks, after which they were permitted to dry slowly in laboratory air until tested. The gravel concrete was made in three wetnesses. The wettest specimen had as much water as should be used in ordinary construction; the driest was of a consistency that could be used for very special work, in which the extra cost of spading, rodding, and tamping the concrete into the form would be justified by the increase in desirable properties which could be obtained by this rather dry concrete.

2. *Building Blocks.*—In addition to the prepared samples, three different building blocks were tested. These are listed in Table IV. These blocks were part of a purchase of several hundred made from a manufacturer and contractor in the vicinity of Washington, for use in the construction of protective barriers for the 400-

TABLE III.—SOLID BUILDING BLOCKS

Specimen	Dimensions	Density
	Inches	g./cm.(2)
B4	$3^3/_4 \times 7^1/_2 \times 11^3/_4$	2.0_3
B6	$5^1/_2 \times 6 \times 9$	2.0_2
B8	$7^1/_2 \times 8 \times 13$	2.1_0

[3] We are indebted to John Tucker, Jr., of the Cement Section of the National Bureau of Standards, who selected the test samples and under whose supervision they were prepared.

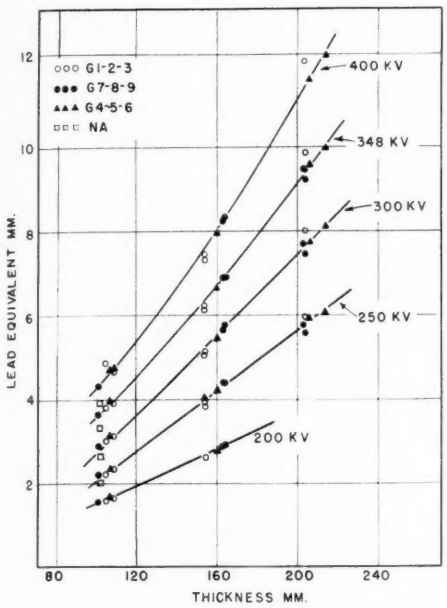

Fig. 2.

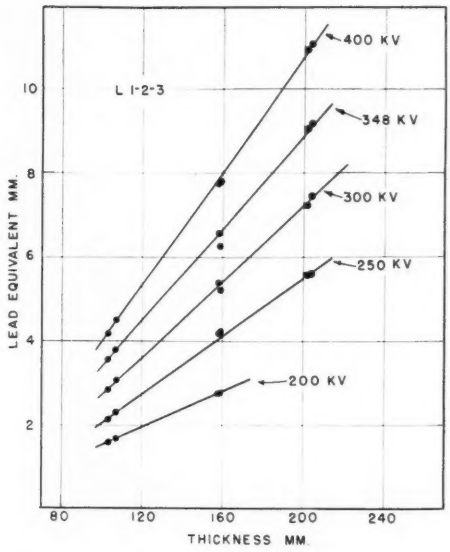

Fig. 3.

Fig. 2. Variation of lead equivalent of a concrete barrier with thickness. (See Table IV for description of specimens.)

Fig. 3. Variation of lead equivalent of a limestone concrete barrier with thickness. (See Table IV for description of specimens.)

kv. x-ray generator of the National Bureau of Standards. Block *B4* was a solid block of rectangular cross-section; blocks *B6* and *B8* had the horizontal cross-section of the usual three-web building block but were solid, that is, the two cylindrical cores ordinarily used in making three-web blocks were omitted. The nature of the mix was not known, except that in accordance with the usual commercial practice the mix was made sufficiently dry to permit prompt removal of the blocks from the machine molds, the ideal mixture for blocks being that which will barely retain its shape when the forms are removed immediately after the concrete has been deposited and pressed into shape. This is a great deal drier than the mixtures ordinarily used in poured concrete.

IV.—RESULTS

1. *Variation of Lead Equivalent with X-ray Voltage and Thickness of Concrete.*—The lead equivalent of each sample was determined at each of the following excitation potentials: 200, 250, 300, 348, and

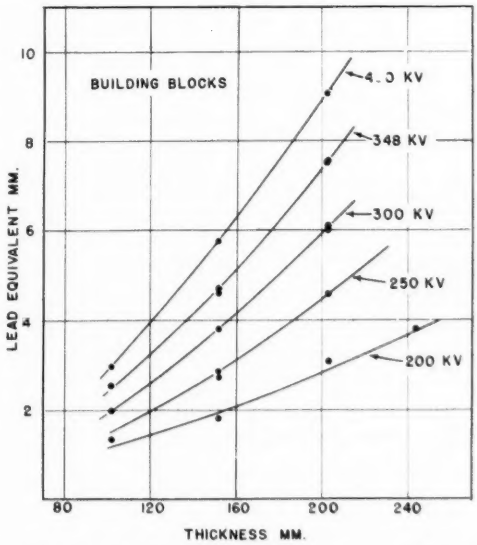

Fig. 4. Lead equivalent of concrete building blocks plotted against thickness of blocks. (See Table V for description of specimens.)

TABLE IV.—LEAD EQUIVALENT OF CONCRETE

Sample	Thickness	Diameter	Density	Lead Equivalent at—					Mass per Unit Cross-section
				200 kv.	250 kv.	300 kv.	348 kv.	400 kv.	
	cm.	cm.	g./cm.(1)	mm.	mm.	mm.	mm.	mm.	g./cm.(1)
G1A	10.5	15.3	2.37	1.60	2.26	3.01	3.82	4.88	24.9
G1B	10.9	15.3	2.37	1.66	2.33	3.13	3.91	4.64	25.8
G2A	15.4	15.3	2.34	2.60	3.86	5.09	6.18	7.42 7.32	36.0
G2B	15.4	15.3	2.34	2.58	3.96	5.12	6.23	7.45 7.42	36.0
G3	20.4	20.4	2.36	....	5.97	8.03	9.86	11.00	48.1
G4A	10.9	15.3	2.47	1.70	2.40	3.17	3.97	4.73	26.9
G4B	10.7	15.3	2.47	1.70	2.37	3.12	3.98	4.66 4.68	26.4
G5A	15.4	15.3	2.36	2.63	4.01	5.13	6.30	7.40	36.3
G5B	16.0	15.3	2.36	2.77	4.20	5.44	6.66	7.97 7.92	37.8
G6A	20.6	20.3	2.40	....	5.80	7.73	9.59	11.59	49.4
G6B	21.4	20.3	2.40	....	6.06	8.11	9.97	12.16	51.4
G7A	10.8	15.3	2.40	1.70	2.34	3.12	3.98	4.68	25.9
G7B	10.1	15.3	2.40	1.58	2.21	2.90	3.64	4.31	24.2
G8A	16.3	15.3	2.40	2.90	4.42	5.64	6.93	8.22	39.1
G8B	16.4	15.3	2.40	2.93	4.40	5.77	6.92	8.32	39.4
G9A	20.4	20.3	2.37	....	5.59	7.47	9.23	11.29	48.3
G9B	20.3	20.3	2.37	....	5.76	7.70	9.48	11.58	48.1
G10A	10.1	....	....	1.49	2.00	2.70	3.47	4.02	....
G10B	10.6	....	....	1.58	2.16	2.95	3.69	4.33	....
G11A	15.1	....	....	2.36	3.74 3.73	4.89	5.97	7.02 7.06	....
G11B	15.5	....	....	2.55	3.92	5.10	6.23	7.42 7.33	....
L1A	10.7	....	2.31	1.67	2.30	3.07	3.80 3.78	4.49	24.7
L1B	10.3	....	2.31	1.57	2.13	2.85	3.50 3.55	4.19	23.8
L2A	15.9	....	2.36	2.77	4.22	5.40	6.56	7.80	37.5
L2B	15.8	....	2.36	2.78	4.19	5.39	6.57	7.76	37.3
L3A	20.4	....	2.31	....	5.61	7.45	9.19	11.10	47.1
L3B	20.2	....	2.31	....	5.57	7.33	9.02	10.92	46.7
NA	10.2	....	2.12	1.52	2.03	2.69	3.34	3.92	21.6
NNA	10.3	....	2.12	1.52	2.00	2.68	3.34	3.90	21.8
X	20.7	....	....	....	5.72	7.67	9.44	11.52	....
B4	....	....	....	1.33	1.48	1.99	2.53	2.99 2.98	19.5
B6	....	....	....	1.80	2.74 2.76 2.89	3.80	4.65 4.60 4.70	5.76 .... 5.73	29.7
B8	....	....	....	....	4.58	6.03 6.07	7.52 7.50	9.04	41.6

400 kv. No beam filter was used, the only filter being 2 mm. of copper and 10 mm. of aluminum inherent in the x-ray tube.

The results of these tests are tabulated in Table IV and are plotted in Figures 2, 3, and 4. It is apparent from these data that the lead equivalent of a sample of given density depends not only on its thickness but also on the x-ray excitation potential as well, and above 200 kv. increases with both.[4]

2. *Variation of Protection Coefficient with Density.*—Figure 5 is a typical plot of the protection coefficients as a function of density for samples of approximately equal thickness.[5] The samples of Figure 5 were cylinders approximately four inches thick; similar plots were made for samples six and eight inches thick. The lines were drawn

[4] The complete curve showing the lead equivalent of concrete as a function of the excitation potential has a minimum at approximately 200 kv. and a low maximum at about 100 kv. However, the portion of the curve below 200 kv. is of little practical value.

[5] "Protection coefficient" has been defined as follows by the American Advisory Committee on X-ray and Radium Protection: "The protection coefficient of a material is the ratio of the thickness of lead to the thickness of the material which absorbs a given x-ray beam to the same extent."

so as to pass through the origin of the coordinate system as they would do if the protection coefficient varied linearly with differences in their protective coefficients can be explained simply in terms of their densities.

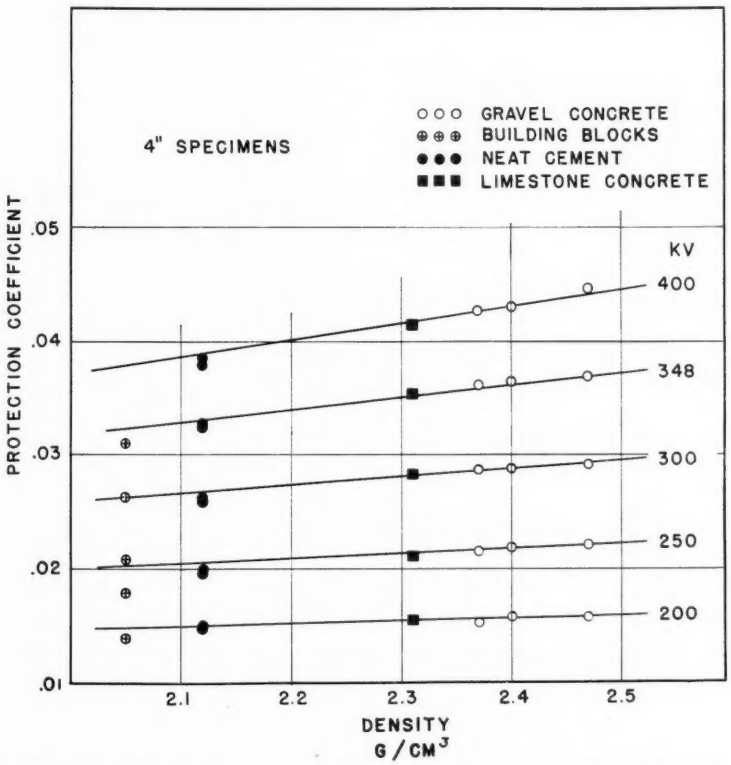

Fig. 5. Variation of protection coefficient of four-inch concrete test cylinders with density of specimens.

the density of the concrete. It appears that within the experimental error of the measurements the points do fall on the lines so drawn, and we may, therefore, conclude that within this quality range the protection coefficient of concrete is directly proportional to the density of the concrete. It follows that in this range the components of the concrete mix do not directly affect the protective quality of the material aside from their effect on the concrete density. In Figure 5, four different concrete mixes are included: Two specimens are neat cements, one is a limestone concrete, three are gravel concretes, and two are building blocks of unknown composition; yet the observed

3. *Thickness of Concrete Required for Protection.*—Since there are no striking differences in the lead equivalents of samples of equal density but varying composition, there is no particular advantage in making tests on many different samples; and, therefore, all subsequent measurements extending these tests to lead equivalents greater than the recommended lead thicknesses were confined to two groups of samples designated as *G* (density 2.36) and *B* (building blocks, density 2.0 to 2.1_0). These data are summarized in Table V and are plotted in Figures 6 and 7. In these figures, the intersection of the dotted curve with the full-line curves gives

the thickness of this concrete required to give the degree of protection recommended by the Advisory Committee on X-ray and Radium Protection. For concrete of some slightly different density, the required thickness can be obtained if its density is

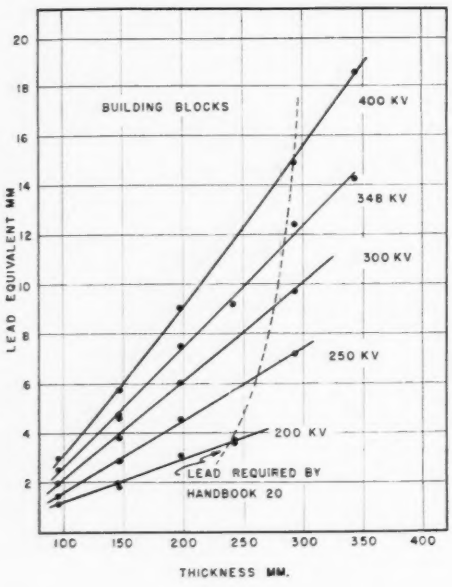

Fig. 6.

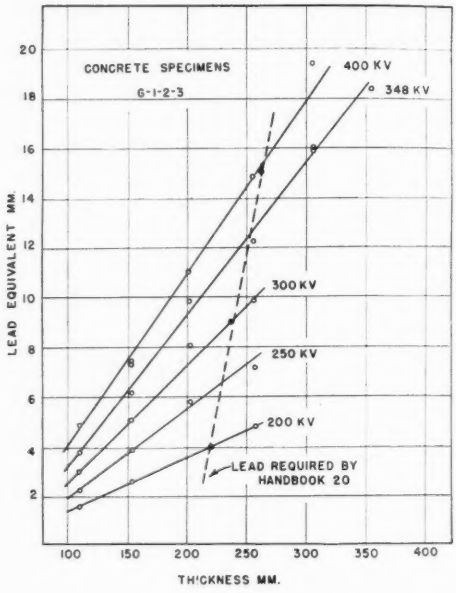

Fig. 7.

Fig. 6. Curves for obtaining required thickness of barrier made of building blocks of average density 2.05 g./cm. (1).

Fig. 7. Curves for obtaining required thickness of concrete barrier of average density 2.35 g./cm. (1).

TABLE V.—LEAD EQUIVALENT OF CONCRETE

Sample	Average Density	Thickness	Lead Equivalent					Mass per Unit Cross-section
			200 kv.	250 kv.	300 kv.	348 kv.	400 kv.	
	g./cm. (1)	cm.	mm.	mm.	mm.	mm.	mm.	g./cm. (1)
G1A	2.37	10.5	1.59 1.60	2.26	3.01	3.82	4.88	24.9
G2A	2.34	15.4	2.60	3.86	5.09	6.18	7.42 7.32	36.0
G3	2.36	20.4	....	5.97	8.03	9.86	12.00	48.1
G1A + *G2A*	2.35	25.9	4.79	7.14	9.81	12.2 12.2	14.8	61.1
G1A + *G3*	2.36	30.9	....	....	....	15.9 15.8	19.3	72.9
G2A + *G3*	2.35	35.8	....	....	....	18.3	....	84.1
B4	2.0$_2$	9.6	1.15 1.33	1.48	1.99	2.53	2.99 2.98	19.5
B6	2.0$_2$	14.7	1.89 1.80	2.74 2.76 2.89	3.80	4.65 4.60 4.70	5.76 5.73	29.7
B8	2.1$_0$	19.8	3.0$_7$	4.58	6.03 6.07	7.52 7.50	9.04	41.6
B4 + *B6*	2.0$_2$	24.3	3.58 3.90 3.67	....	....	9.14	10.5	49.1
B4 + *B8*	2.0$_7$	29.4	....	7.1$_8$	9.6$_2$	.....	14.2 14.9	61.2
B6 + *B8*	2.0$_6$	34.5	....	....	.....	14.2	18.5	71.7
Required for adequate protection	....	....	4.0	....	9.0	.....	15.0	....

known, since for samples of approximately equal thickness the lead equivalent varies linearly with density. However, in using Figures 6 and 7 to compare concretes of widely different densities, it should be remembered that the protection coefficient of a sample depends also on the sample thickness; therefore, to determine the required thickness of any concrete it should be compared with a concrete of greater rather than with one of lesser density; by making this determination in this way a thickness somewhat greater than that required will be obtained and the error resulting will be on the safe side.

4. *Variation of Lead Equivalent of Concrete with Mass per Unit Area.*—All absorption data on concrete given above for various mixes, densities, and thicknesses are conveniently summarized in Figure 8, in which the lead equivalent of a concrete barrier is plotted against the mass of the barrier per unit cross-sectional area. For a given voltage, all samples in this graph fall on a single curve, no matter what the composition, density, or thickness of the individual samples may be. For this reason, the thickness of a concrete barrier required for adequate protection can be most conveniently obtained from Figure 8 by use of the relation $L = M/D$, where L is the thickness of concrete barrier; M is the mass of barrier per unit area required to give the desired degree of protection—obtained from Figure 8, and D is the density of the concrete used.

As has already been noted, the curves in Figures 6 and 7 must be used with caution when the density of a given concrete is widely different from those used as standards in these two graphs. It is clear that no such precautions are necessary in making the same determination by means of Figure 8 and for this reason its use is recommended.

5. *Concrete-lead Mass Ratio.*—In Figure 8 the dotted curve is for metallic lead; this is included for the purpose of comparing the mass of a concrete wall with that of a lead barrier providing equivalent protection. Table VI contains a summary of such a comparison for 200-, 300-, and 400-kv. radiation.

In column 5 of Table VI there are given the ratios of the mass of a concrete barrier to the mass of its lead equivalent. The ratio is high at the lower excitation potentials; at 200 kv. an adequate concrete barrier has about twelve times the mass of

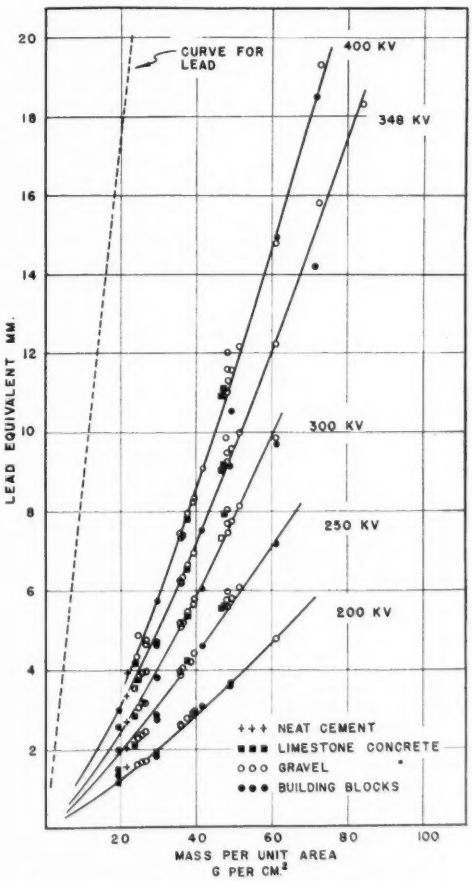

Fig. 8. Lead equivalent of any concrete barrier as a function of the mass of the barrier per unit cross-sectional area.

TABLE VI.—CONCRETE-LEAD MASS RATIO

Potential	Recommended Lead Equivalent	Mass per Unit Area		Mass of Concrete / Mass of Lead
		Lead	Concrete	
1	2	3	4	5
kv.	mm.	g./cm.	g./cm.	
200	4.0	4.5	53	11.8
300	9.0	10.2	57	5.6
400	15.0	17.0	60	3.5

its lead equivalent, while at 400 kv. the concrete barrier has only three and a half times the mass of an equivalent lead shield.

V.—CONCLUSION

Since the protection coefficient of concrete increases rapidly with increasing excitation potential, the thickness of the concrete barrier which will provide adequate protection at, say, 400 kv., is not very much greater than that required to give the same degree of protection at a much lower voltage. So, from Figure 6, we see that for the building blocks tested, a barrier about 30 cm. (11.8 in.) is adequate at 400 kv., while at 200 kv. the thickness required is about 22 cm. (8.7 in.). Similarly, from Figure 7, the thickness of concrete required at 400 kv. is about 26.5 cm., while the required thickness at 200 kv. is 22 cm.

In both cases the additional thickness required in going from 200 to 400 kv. is small and a barrier providing adequate protection at a given excitation potential will also be adequate at a lower voltage.

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THE VALUE OF RADIOGRAPHY OF THE GALL BLADDER IN THE UPRIGHT POSITION[1]

By RAMSAY SPILLMAN, M.D., *New York City*

THREE years ago, Dr. Alice Ettinger, of Boston,[2] called attention to a phenomenon which, in a bibliography listed by her, had been described before only by Åkerlund, Eliasz, and Bernstein. This communication put me on guard to use the upright position in radiographing the gall bladder, in addition to the recumbent, with the result that in one instance, thus far, an incontrovertible diagnosis of small gallstones was made in a case in which the films made prone showed a normal gall-bladder shadow and no trace of stones.

The principle is extremely simple, and the only reason for reporting this case is to add a note of emphasis as to the value of the procedure. It depends on the following elementary principle: in the upright patient, the gall-bladder contents of highest specific gravity, whether gallstones or bile, gravitate to the fundus of the viscus. In certain cases there is a collection of minute gallstones, comparable in size to canary bird sand, of lower specific gravity than the bile in the most dependent part of the gall bladder, and of higher specific gravity than that in the uppermost part of the gall bladder. In the upright position, this collection forms a radiolucent layer somewhere between the upper and lower end of the gall bladder. In the prone position, it is entirely lost in the shadow of the dye.

In the case here reported, a young woman with textbook history of gallstone colic, the diagnosis would have been entirely missed on the prone films alone.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Am. Jour. Roentgenol. and Rad. Ther., **35,** 656–661, May, 1936.

Fig. 1.

Fig. 2.

On films made in the standing position with the Lysholm grid on the fluoroscope, the clear layer remained horizontal when the patient bent far over to either the right or the left, proving its analogy to a fluid level. The film from which the darker of the two prints was made (Fig. 2) shows clearly a foamy structure of the clear layer, in which individual granules can be clearly discerned.

SUPPURATION IN THE MASTOID AND PETROUS PORTIONS OF THE TEMPORAL BONE: ROENTGEN FINDINGS[1]

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THE temporal bone is composed of four parts: the mastoid process, the petrous pyramid, the squamous, and tympanic portions. The mastoid process and the petrous pyramid are the portions of particular interest because of the prevalence of suppurations within these parts of the temporal bone.

A roentgen study of the temporal bone should include an examination of the mastoid processes and the petrous pyramids. The Law position, or a modification of it, is usually employed for the mastoid processes, and a film of the base of the skull or some other position, for the petrous pyramids. The examination may include other and additional positions, depending upon the type and location of the lesion which is under investigation. Individual preferences enter here. Other positions commonly employed are: Obliques for the mastoid tip, modifications of the Law position, Stenvers, Schüller, Mayer, Granger, MacMillan, and others. When complications to otitic infections are under investigation, it is desirable and often necessary to utilize several of the above-named positions, in order to arrive at a diagnosis.

At birth, the temporal bone is not pneumatized. The mastoid antrum is the only cell present. Pneumatization of the mastoid portion of the temporal bone is a normal process. According to Wittmaack, this follows the invagination of the epithelial lining of the middle ear into the diploic bone of the mastoid process, and the replacement of the latter by the subsequent development of pneumatic cells. Associated with this, there is a proliferation of the embryonal myxomatous connective tissue.

The process of pneumatization in the petrous pyramid is identical with that in the mastoid. It starts either from the inner antral wall, the epitympanic space, or from the peritubal region, and goes forward to the petrous tip. Anything which interferes with the normal process of pneumatization will result in an undeveloped mastoid, or cause a faulty type of pneumatization, with the result that throughout life there will be either a diploic or an incompletely pneumatized mastoid process. This also holds true for the petrosa.

Pneumatization varies considerably, and does not respect boundaries or suture lines. When pneumatization is extensive it may extend into the zygoma, squamosa, occipital bone adjacent to the mastoid, and also into the basilar process of the occipital bone. Pneumatization in the temporal bones is usually symmetrical. Asymmetrical pneumatization does occur, but infrequently.

The mastoid process is usually pneumatized between the ages of three and five. Before the age of three, little or no pneumatization may be present.

Roentgenograms of the temporal bone reveal the following anatomical landmarks:

(A) Mastoid Process.
  (1) Size of mastoid.
    (*a*) Small or large.
    (*b*) Cellular development.
      Extensions—zygoma, squamosa, occipital bone, etc.
  (2) Character of structure.
    (*a*) Small cells.
    (*b*) Large cells.
    (*c*) Mixed small and large cells.
    (*d*) Undeveloped.
      Diploic bone.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

(*e*) Sclerotic bone.
(*f*) Combinations of any of the above.
(3) Internal and external auditory meatuses.
(4) Region of the mastoid antrum.
(5) Posterior canal wall.
(6) Tegmen tympani and mastoidei.
(7) Lateral sinus, knee and sigmoid sinus.
(8) Sigmoid sinus wall—ridge on posterior surface of pyramid.
(9) Mastoid tip.
(10) Emissary vein.
(11) Semicircular canals.
(12) Eustachian tube (osseous portion in sclerotic mastoid).

(B) Petrous Pyramid.
(1) Pneumatization.
(2) Character of structure.
(*a*) Small cells.
(*b*) Large cells.
(*c*) Diploic bone.
(*d*) Mixed small and large cells.
(*e*) Mixed diploic and pneumatic cells.
(*f*) Sclerotic bone.
(3) Apical-carotid portion.
(*a*) Tip.
(*b*) Middle lacerated foramen.
(*c*) Superior border—middle fossa.
(*d*) Carotid canal.
(*e*) Superior petrosal sinus.
(*f*) Inferior petrosal sinus.
(*g*) Jugular fossa.
(*h*) Area for Gasserian ganglion.
(*i*) Internal auditory meatus.
(*j*) Subarcuate fossa.
(4) Labyrinthine portion.
(*a*) Arcuate eminence.
(*b*) Superior semicircular canal.
(*c*) Horizontal and posterior semicircular canals.
(*d*) Cochlea.
(*e*) Superior surface.
(5) Post-labyrinthine portion.
(*a*) Mastoid process.
(*b*) Lateral sinus.
(*c*) Sigmoid sinus.
(*d*) Styloid process.
(*e*) External auditory canal.

(C) Base of Skull.
(1) Petrosæ (and adjacent structures).
(*a*) Pneumatization.
(*b*) Character of structure.
(*c*) Apical-carotid portion.
(*d*) Labyrinthine portion.
(*e*) Post-labyrinthine portion—mastoid.
(*f*) Middle lacerated foramen.
(*g*) Superior petrosal sinus.
(*h*) Inferior petrosal sinus.
(*i*) Jugular fossa or posterior lacerated foramen.
(*j*) Lateral and sigmoid sinus.
(*k*) Foramen magnum.
(*l*) Basilar process of occipital bone.
(*m*) Region of Eustachian tube.
(*n*) Foramen ovale.
(*o*) Foramen spinosum.
(*p*) Foramen rotundum.

PATHOLOGICAL MASTOID

(*A*) *Non-pneumatic.*—Pneumatization is the normal process. If the epithelium lining the mastoid antrum is the site of a pathological process in early infancy, subsequent pneumatization of the mastoid and petrous portions of the temporal bone will not occur following recovery. An otitis media, either catarrhal or infectious, during infancy, prevents pneumatization or arrests further development when pneumatization has already started. This holds true for the petrous pyramids as well as the mastoid processes. A non-pneumatic mastoid in an adult is indicative that an otitis media existed in early infancy. An incompletely pneumatized mastoid is informative of an otitis media in infancy before pneumatization was complete. A mastoid which is non-pneumatized or incompletely pneumatized usually yields a history of an intermittent, a persistent, or a protracted otorrhea. A destructive inflammatory lesion in a non-

pneumatic mastoid is the equivalent of an osteomyelitis. This is an infrequent occurrence. Low-grade otitic infections in non-pneumatic mastoids usually lead to a productive osteitis, a sclerosis of the mastoid process. A cholesteatoma is a destructive lesion which develops slowly and occurs only in a non-pneumatic mastoid, due to inclusion of desquamated epithelium through a perforation in the tympanic membrane. As the cholesteatomatous mass becomes larger it destroys its bony surroundings Because of the slow-growing nature of this lesion, there is time for the development of a productive osteitis which appears as a layer of compact bone around the area of destruction. This lesion can attain considerable size. Large cholesteatomas are seldom seen to-day. A cholesteatoma may develop following surgery on a pneumatic mastoid. The epithelium inclusions are from the inverted skin margins of the wound.

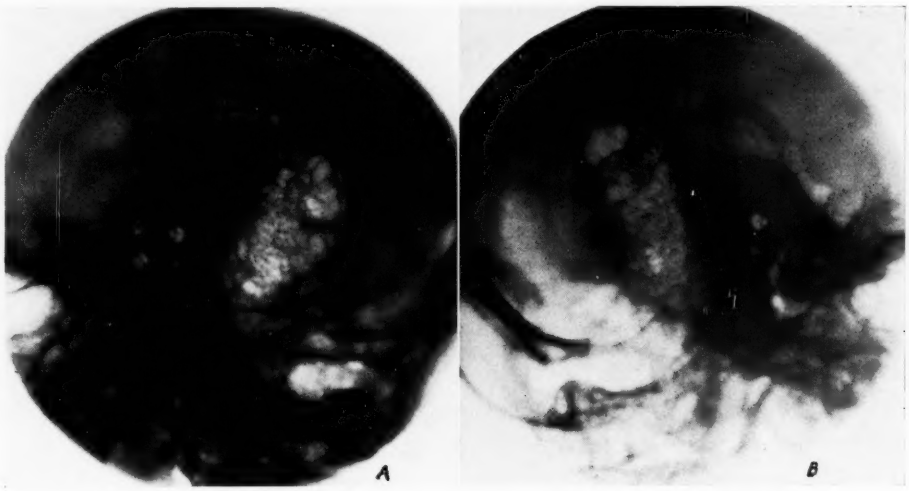

Fig. 1-*A*. Normal, well developed mastoid, composed of small and large cells, with cellular development extending into the squamous and zygomatic areas. Normal aeration.
Fig. 1-*B*. Slight diminution in aeration. Marked diminution in aeration of the antral area. The cell walls are thickened. Loss of definition in the supra- and post-sinal regions. Acute purulent otitis media.

(*B*) *Pneumatic Mastoid.*—The normal mastoid process reveals air spaces with numerous cell walls. The cell walls or trabeculæ appear sharp and dense because of the marked contrast with the air in the cells. The density of the mastoid structure is about the same as that of blood. For this reason the ridge on the posterior surface of the petrous pyramid, referred to as the sinus wall, is not always visualized. The sinus may be situated anteriorly (*i.e.*, close to the posterior canal wall), posteriorly, or in a median position. Its location in relation to the posterior canal wall is of importance to the surgeon in affording him a guide as to its position within the mastoid. The sinuses which were well forward on a roentgen film were found at operation to be superficial as well. In the undeveloped type of mastoid the sinus is usually forward. The mastoid emissary vein is usually situated midway between the tip of the mastoid and the knee of the sinus. The location of this vein is of importance to the surgeon, enabling him to avoid accidental injury and unnecessary bleeding during operation.

Pathological processes are recognized because they reduce the air content in the cells, and also produce changes in the cell walls.

Acute Otitis Media.—As the name indicates, the infection is limited to the middle

ear. Associated with this there is a hyperemia of the contiguous mucous membrane lining all of the air cells, the pneumatic structure, in the temporal bone. The hyperemia results in a temporary slight increase in the thickness of the mucous membrane. Subsequent developments, without extension of the infection into the mastoid or petrous portions, may result in a further displacement of the air from the pneumatic cells by an added increase in the thickness of the mucous membrane because of the congestion, diapedesis and the formation of a transudate. A roentgen examination at this time reveals a diminution in the aeration of the pneumatic structure of the mastoid process and the petrous pyramid. The greatest diminution in aeration is noted in the antrum area. As the lesion progresses, the cell walls appear thick

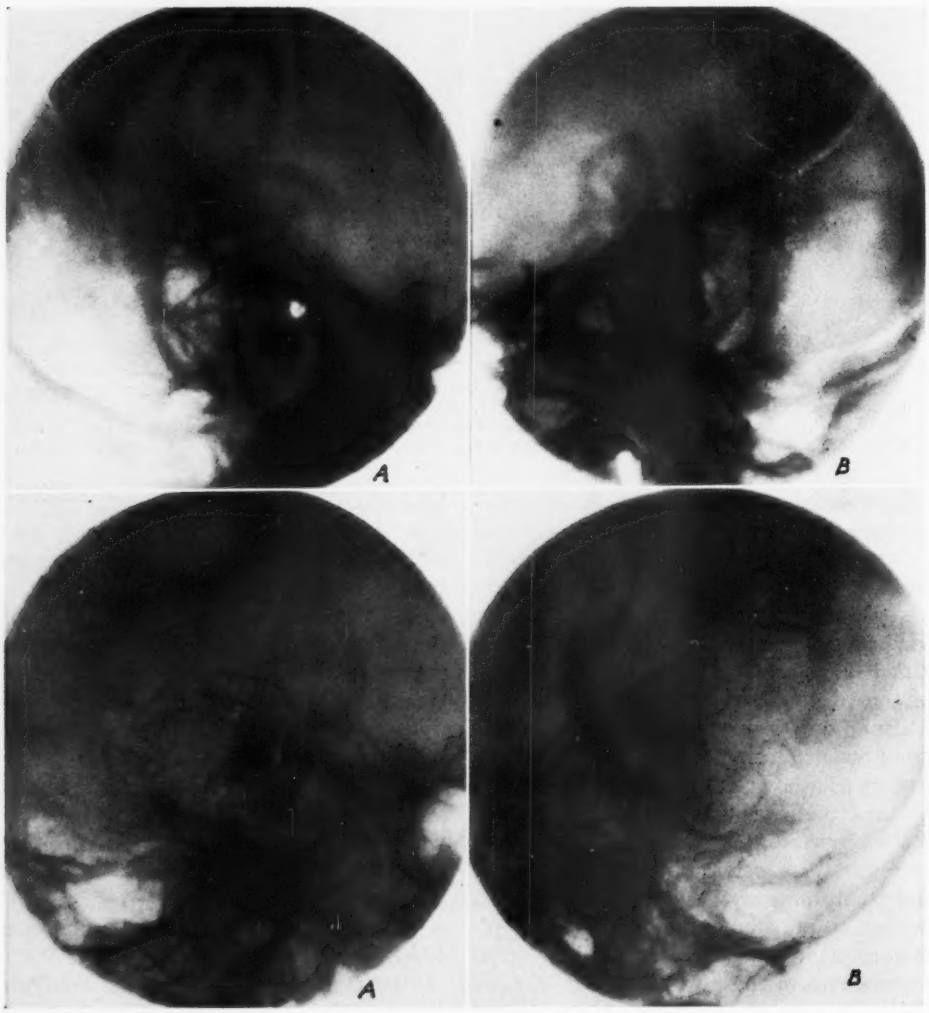

Fig. 2-*A* (*upper left*). Localized destructive lesion—coalescence of smaller cells due to a previous otitic infection.
Fig. 2-*B* (*upper right*). Incomplete pneumatization. Otitis media in infancy arrested pneumatization.
Fig. 3-*A* (*lower left*). Large, normal well developed mastoid.
Fig. 3-*B* (*lower right*). Diminished aeration. Decalcification and destruction of cell walls in the squamosa, supra- and post-sinal regions. Sinus wall distinctly visualized and intact. Destructive mastoiditis.

and less sharply defined. The contrast between the cell wall and the air cell is less marked. The density of the mastoid is increased. The sinus wall becomes visible.

As the otitis media resolves there is a gradual return to normal. If, instead of resolution, the infection extends into the mastoid process and produces a destructive lesion, the roentgen findings on serial study will show the development of the destructive lesion. The hyperemia persists, the transudate becomes an exudate, and the air cells contain all the products of inflammation. Even though an aural discharge is present, drainage is not adequate. The cell walls begin to lose density, due to the hyperemia and increased intracellular pressure. There is gradual decalcification, softening, and breaking down of the cell walls. Granulations develop. If permitted to continue, a large coalescent abscess forms. The sinus wall and tegmen are dense and appear intact. Dehiscences or destructive changes in the sinus wall or tegmen denote complications. Perforation may occur at the tip, or subperiosteally in the mastoid, squamous, or zygomatic areas. Rarely is the petrous pyramid involved simultaneously.

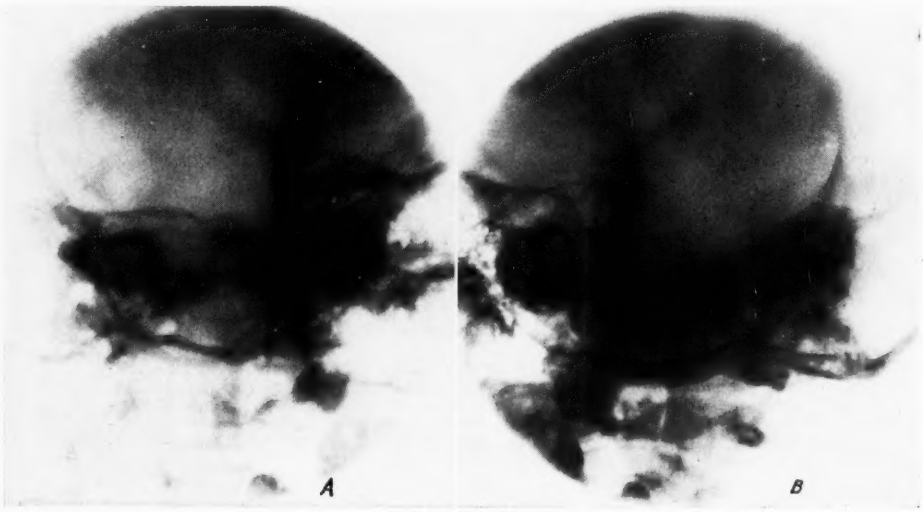

Fig. 4-*A*. Normal petrous pyramid. Superior margin intact.
Fig. 4-*B*. Localized decalcification of superior margin extending forward from subarcuate fossa into apical-carotid portion of pyramid. Epidural abscess.

All acute otitic infections, regardless of their type or location, will produce a decrease in aeration when compared with the healthy side. Consequently one cannot base an opinion on a variation in density alone. Only intramastoidal diseases will cause a partial or total destruction of the intercellular structure. Bearing this in mind, the classification of mastoid diseases from a roentgen standpoint into those which destroy structure and those which do not, becomes evident. A diminution in the aeration of the mastoid process, with intercellular walls and all other anatomical landmarks remaining intact, will also be found in furunculosis, post-auricular adenitis, and cellulitis.

It is an established fact that with every acute purulent otitis media there is a concomitant hyperemia or edema in the mastoid process. Just when an acute purulent otitis media becomes an acute mastoiditis must be left to the otologist. From the roentgen standpoint, it is not known whether a diminution in aeration of the

mastoid process, with intact cell walls, is due to an acute purulent otitis media or an early acute mastoiditis of a surgical nature.

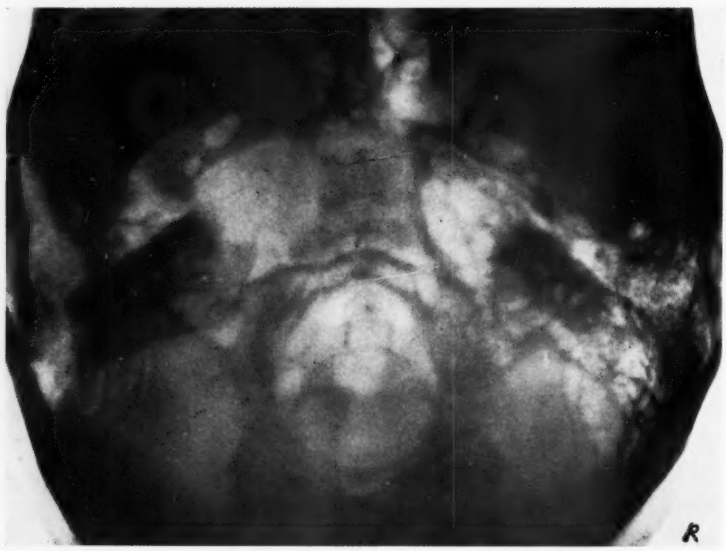

Fig. 5. Right petrous pyramid—normal. Complete pneumatization of apical-carotid portion. Labyrinthine area shows considerable cellular development.
Left petrous pyramid—Complete destruction of all cell walls in the apical-carotid portion. There is a marked diminution in aeration of the cells in the labyrinthine area. Suppuration in apical-carotid portion of pyramid. (Clinical—drainage inadequate.)

There is one type of acute mastoiditis wherein the cell walls remain intact—the acute hemorrhagic mastoiditis. This lesion presents numerous small punctate areas of atrophy in the cell walls and a diminution in aeration. The cell walls are intact throughout the entire course of the disease.

As a rule, the size of the mastoid as determined in a roentgenogram is of little value to the clinician. It becomes important, however, in those cases of protracted acute purulent otitis media in which, in spite of the absence of all systemic and local symptoms, the otological picture is that of an acute mastoiditis. In such a case, the finding of extensive pneumatization toward either the squamosa, zygoma, occipital bone, or petrosa, or all of these regions, informs the otologist that extensive destruction must take place before local and general symptoms are manifested clinically. On the other hand, a small-sized mastoid process, as seen on the roentgenogram, will warn the otologist of the possibility of an erosion of the inner table, if operation is delayed too long, in a protracted case.

Resolution in mastoid infections occurs with considerable frequency. All acute infections do not produce large coalescent abscesses requiring surgery. At times, an infection from an otitis media extends into the mastoid, produces one or more localized areas of destruction, and then resolves.

In any one individual, the mastoid processes are usually of the same size and type. Consequently, in a pneumatic mastoid there should be the same cellular development and distribution in both mastoids. However, the size and position of the cells are important only in a comparative way. Where in one area of the uninvolved mastoid one finds small cells, and where in the same area in the involved mastoid large cells are present, it is significant of a destruction of the intercellular septa in this location, resulting in the formation of large

cells from the coalescence of smaller ones. This may be the end-result of a previous otitic infection.

An extension of the infection into the petrous pyramid may occur with an otitis media, or a mastoiditis, or both, or appear as a complication following surgery. The structure of the pyramid may be pneumatic, non-pneumatic, or a combination of both.

Suppuration in the apical-carotid portion of the petrous pyramid may occur in any type structure of bone. If the petrous pyramid is composed of diploic bone, an osteomyelitis results. When pneumatization is present, changes result which are analogous to a suppurative lesion in a pneumatized mastoid process—a coalescent petrositis or an empyema.

Roentgenographically, the pneumatic petrous pyramid shows a change from the normal with any otitic infection, and is observed as follows:

1. *Acute Purulent Otitis Media.*—The petrous pyramid shows a generalized diminution in aeration. The trabeculæ appear thickened and are intact. There are no destructive changes. There is no atrophy. The apical contour is distinctly visualized and is intact. This accompaniment to an acute otitis media is not due to a suppurative lesion in the petrous pyramid. The diminution in aeration of the petrous pyramid is due to a congestion and edema of the mucous membrane lining the air spaces. The mastoid process is the site of a similar change in aeration at the same time. The change in aeration of the pyramid is so pronounced when compared to the normal side, that the diseased ear can be detected from the appearance of the petrous pyramid.

2. *Acute Coalescent Mastoiditis.*—The petrous pyramid also shows a diminution in aeration when there is an extension of the infection from the middle ear into the mastoid process, resulting in a destructive or coalescent mastoiditis. The findings are essentially the same as those found with an acute otitis media; they are more pronounced, because the congestion and edema in the petrous pyramid are more marked. There is a marked decrease in aeration, a generalized increase in density. The trabeculæ, while thickened, show *no evidences of softening or destruction.* There is no atrophy, and the contour of the apical-carotid portion of the pyramid is visualized and is intact. These changes do not indicate a suppurative lesion in the petrous pyramid. Even after mastoidectomy for a coalescent mastoiditis, the petrous pyramid will show a similar change, until there is complete restitution to normal.

3. *Chronic Suppurative Otitis Media.*—The petrous pyramid shows a generalized diminution in aeration where a pneumatic petrosa is found. However, a pneumatized pyramid is the exceptional rather than the usual finding in the presence of a chronic purulent otitis. There is no atrophy and there are no destructive changes. There is no infection in the petrous pyramid. The diminution in aeration is due to the attendant congestion and edema of the mucous membrane, when present. A cholesteatoma does not enter into the discussion for it does not occur in a pneumatic bone.

4. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid, with Inadequate Drainage.*—The petrous pyramid shows a diminution in aeration with an increase in density in the basal or labyrinthine portion. The apical-carotid portion of the petrous pyramid shows a marked decrease in density. There is a marked decalcification of the entire medial portion. The trabeculæ may show evidences of softening or destruction, these changes becoming more pronounced as the lesion progresses. The halisteresis may be so intense that the contour of the apical-carotid portion is visualized either faintly or not at all. The fact that the contour of the apical-carotid portion of the petrous pyramid is not visualized does not indicate perforation. As the lesion progresses, perforation and destruction of the apex may ensue. These changes are quite striking, and the demarcation between the apical-carotid and labyrinthine portions is definite and pronounced, and due to a suppurative

lesion in the apical-carotid portion of the petrous pyramid—an empyema. If drainage from the suppurative lesion is inadequate, the roentgen findings accompany a given symptom-complex, and surgery is required to avoid an intracranial complication. This lesion is an acute one, and surgery is necessary as a life-saving measure.

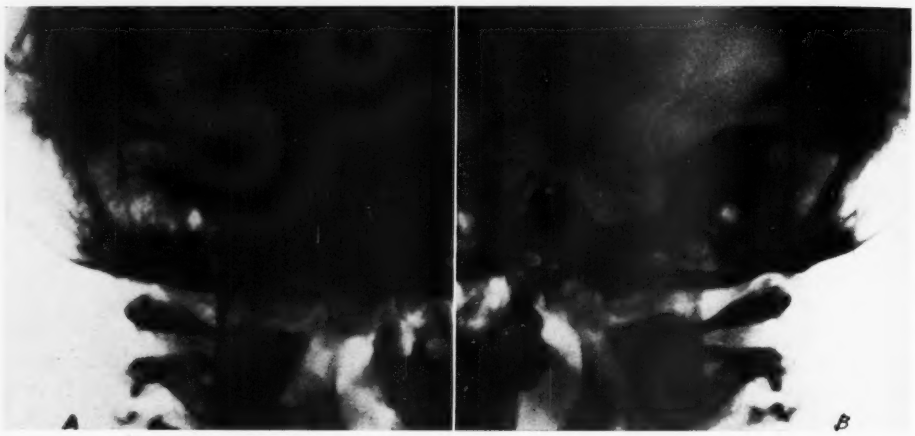

Fig. 6-*A*. Normal petrous pyramid.
Fig. 6-*B*. Clinical and roentgen examinations: suppurative lesion in apical-carotid portion of petrous pyramid. The contour of the apical-carotid portion of the pyramid is not visualized, due to complete decalcification.

5. *Suppuration in the Apical-Carotid Portion of the Petrous Pyramid, with Adequate Drainage.*—The changes in the appearance of the pyramid are essentially the same as those described when drainage is inadequate. The demarcation between the apical-carotid and labyrinthine portions may not be so pronounced. The basal portion of the pyramid shows a decrease in aeration, an increase in density. The trabeculæ may be partially or completely softened or destroyed. The apical-carotid portion is decalcified. The contour of the apical-carotid portion may or may not be visualized. The spontaneous institution of adequate drainage, development of a fistulous tract wide enough to permit drainage, through the middle ear or wound, modifies the clinical picture, and may prevent an intracranial complication. This lesion may continue and be the cause for a persistent otorrhea. This lesion can be considered as subacute, for drainage is adequate and surgery as a life-saving measure is not necessary. It is possible for inspissated pus or granulation tissue to occlude the fistulous tract and interfere with drainage. When this happens, the clinical picture is that of an acute type process as described in the foregoing paragraph. It is conceivable for a given case to present alternately periods with grave symptoms and periods of well-being; in other words, to oscillate between the acute and subacute from the clinical standpoint, even though the roentgen findings are identical. Cases with adequate drainage may go on to spontaneous healing.

6. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Persistent Otorrhea.*—After mastoid surgery, a number of cases have a persistent otorrhea. Some of these have the source of the infection in the petrous pyramid. These pyramids show a generalized diminution in aeration, with a generalized increase in density. There is a partial sclerosis of the pyramid—productive osteitis secondary to the infection in the petrous pyramid. The remaining trabeculæ become markedly thickened. These reparative changes are superimposed upon the original destruc-

tive lesion. This lesion may follow an otitic infection without mastoid involvement as well as an empyema in the apical-carotid portion with adequate drainage, in instances in which there has been a destruction of the trabeculæ. There is no restitution of trabeculæ, there is no redevelopment of air cells, but there develops a productive bone change secondary to the infection in the petrous pyramid.

7. *Healed Suppurative Lesion in the Petrous Pyramid.*—The petrous pyramid shows a generalized increase in density. Restitution occurs by a productive bone change. The pneumatic structure is replaced by dense compact bone. There is no reformation of cells.

The roentgen findings in the above illustrated types of otitic infections may be divided into two main groups. First, those types which show halisteresis of the apical-carotid portion of the petrous pyramid, of which there are two; and second, those types which do not show halisteresis of the apical-carotid portion, of which there are five. A suppurative lesion in the apical-carotid portion of the petrous pyramid is present in the two types which show halisteresis, and in only one type showing an increase in density—a productive bone change.

The suppurative lesion in the apical-carotid portion of the pyramid, depending on the history, clinical and roentgen findings, may be designated as either acute, subacute, or chronic.

1. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Acute.*—The history is usually that of a simple mastoidectomy on an extensively pneumatized bone followed by a normal convalescence. After a period of well-being—which may be from a few days to several weeks and sometimes months—there is a sudden reappearance of an aural discharge, a low grade sepsis, and pain along the ophthalmic branch of the fifth nerve. The pain is usually located in or behind the eye. This symptom-complex was described by Kopetzky and Almour, and is due to the inadequate drainage of the abscess or empyema in the apical-carotid portion of the pyramid. At operation, several cases showed fistulous tracts which did not permit adequate drainage. A roentgenogram shows findings as previously described under suppuration with inadequate drainage (paragraph 4, above). This type of case requires immediate surgical intervention. It is the only type which is of immediate concern to the otologist, for, if left alone, an intracranial complication with a fatal outcome is certain to follow.

2. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Subacute.*—The persistence of an aural discharge following a recent simple mastoidectomy on a pneumatized mastoid is the history usually obtained. There may be no clinical symptoms other than an otorrhea. A roentgenographic examination reveals the changes described above under suppuration with adequate drainage (paragraph 5, above). Here a fistulous tract is present which adequately discharges the contents from the apical-carotid portion of the pyramid externally. When drainage is adequate, surgery as a life-saving measure is not necessary, but should be undertaken if a chronic otorrhea is to be avoided. The symptom-complex described by Kopetzky and Almour is absent.

3. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Chronic.*—A history of mastoid surgery may or may not be present. The usual history is that of mastoid surgery, followed by a persistent otorrhea, and often there is a history of one or more revisions. The roentgen findings are those described under suppuration with persistent otorrhea (paragraph 6, above).

From the foregoing it is quite apparent that a history of the case is essential to the correct interpretation of the roentgen findings in the petrous portions of the temporal bone, irrespective of the nature of the otitic infection—whether it be acute, subacute, or chronic. Many cases may suggest petrosal suppuration, but, when subjected to careful analysis, prove not to be. The combined evaluation of clinical

symptoms by the otologist and the interpretation of roentgen findings by the roentgenologist will avoid errors in diagnosis.

Fig. 6-*C*. Lipiodol instilled into apical-carotid portion of pyramid. No evidences of perforation.

It is, therefore, of the utmost importance to remember that only those changes in the roentgenogram are to be considered as diagnostic which point to a destructive lesion. A change in density, or diminished aeration alone is not indicative of a suppurative process in the petrosa.

All cases of suppuration in the petrous pyramid, diagnosed and operated upon, may be verified at operation by the instillation of lipiodol, through the fistulous tract if present, through the drill hole made by the Almour operation, or by the procedures recommended by Eagleton or Myerson. Dr. Lempert described apicectomy, which is a complete exenteration of all the cells within the apical-carotid portion of the petrous pyramid. Only by the use of contrast substance can a perforation in the apical-carotid portion of the pyramid be definitely determined. I have seen cases in which the halisteresis was intense and perforation suspected because the apical contour was not visualized. Roentgen examination in these cases after the instillation of lipiodol showed no escape of the contrast substance from the confines of the petrous pyramid. Other cases in which the contour of the petrous pyramid was completely visualized and appeared intact, showed escape of the lipiodol into the cranial cavity. The contrast substance may escape into the anterior, middle, and posterior fossæ, and also over to the opposite side, or it may be localized at the site of the perforation.

I wish to call attention to the importance of a routine roentgenogram of the base of the skull at the time of the roentgen examination of the mastoid processes. This film is of considerable value. Should a subsequent lesion develop in the petrous pyramid, a film to detect changes by comparison is available. When a lesion is suspected in the petrous pyramid, anteroposterior oblique views, or in the Stenvers position, should be made in addition to a

film of the base of the skull. I prefer a film of the base of the skull in diagnosing suppurative lesions in the petrous pyramid. The oblique views may help to confirm or corroborate the findings of a suppurative lesion, and are also of real value in the detection of an epidural abscess in the anterior portion of the pyramid which cannot be recognized on a film of the base of the skull.

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THE PHYSICAL PRINCIPLES OF SLIT KYMOGRAPHY[1]

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THE development of the roentgen kymograph and its increasingly important position in x-ray diagnosis make it desirable at this time to correlate the physical principles underlying the method. This is peculiarly important in this field which is primarily concerned with a physical process movement.

Slit kymography is essentially a process in which an image of a moving object formed by any type of radiation is permitted to fall upon a screen opaque to the radiation and bearing one or more transparent slits. A surface sensitive to the radiation is moved past the slit, or the slit-bearing screen is moved past the sensitive surface. The developed image is the kymogram.[2]

Fundamental Considerations.—We shall designate the slit width by s (cm.) and assume that the movement of the film is in a direction at right-angles to the slit and with constant speed v (cm. per sec.). Every point of the film which passes the slit is exposed to the ray during a time equal to s/v seconds. This may be called the *characteristic time.*

Thus if the slit width is 0.4 mm. = 0.04 cm., and the speed of the film 1.2 cm. per second, the exposure of any point on the film passing the slit is equal to the characteristic time and is $0.04/1.2$ = one-thirtieth second. The technical factors (kv., ma., distance, etc.) must be so selected as to produce an acceptable ordinary film of the structure studied in one-thirtieth second.

Suppose, for example, that the structure to be studied is the heart and that the opaque screen bears only one slit. The patient will be placed so that the slit crosses the projection of the heart and intersects the latter at one or two points. Let us suppose, further, that the exposure factors have been so selected that an ordinary film taken with these factors (with one-thirtieth second exposure) would show good contrast, *i.e.*, the heart shadow would be clear white and the lung-field quite black. The kymogram is made with the film moving down, let us say, at the uniform velocity of 1.2 cm. per second and the slit width is 0.4 mm. (as above). Assume further that the exposure lasts two seconds. (N.B.—This exposure would represent quite a large load on the x-ray tube since the power suitable for one-thirtieth second ordinary exposure is applied for two seconds.)

The result of such an exposure would be a kymogram appearing similar to the diagrammatic sketch shown in Figure 1. The blackened areas marked *a* have been exposed to rays which reached the film through the slit and through the relatively transparent lungs. The region marked *b* is the trace of the cardiac shadow. The regions marked *c* are unexposed because throughout the time of exposure the film in these regions was protected by the opaque portions of the slit-bearing screen. The width, or height, of the zones *a* and *b* is, of course, 2.4 cm., corresponding to the distance moved through by the film during the exposure (two seconds at 1.2 cm./sec.). The lateral borders of zone *a* bear serrations, or waves, due to the fact that the width and position of the cardiac shadow were not constant throughout the exposure but varied more or less with the heart beat.

The principal problem of kymography is the analysis of these waves in order to draw conclusions from their characteristics as to the movement of the structure under

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] In this article our attention shall be confined exclusively to slit kymography with x-rays.

examination. In this connection, it is desirable to stress a point which has been often overlooked. The waves on the kymogram can yield directly only information regarding the movement of the *shadow*. Since the shadow does not uniquely determine the shape or size of the structure producing the shadow, a study of the movement of the shadow cannot uniquely determine the movement of the structure. However, as a result of experience, it is possible to draw clinical conclusions from a two-dimensional shadow of a structure. To this extent it should be possible, on the basis of experience, to draw clinical conclusions from an analysis of the kymographic waves.

Just as the two-dimensional shadow can yield no complete information as to the three-dimensional form of an object, so the single-slit kymogram (one-space dimension) can yield no complete information as to the two-dimensional shadow.[3] The kymogram has, however, a new dimension, *time*, so that although it is limited, as stated, it can yield full information with regard to the time course of the one-dimensional entity.

Specifically, in the kymogram of Figure 1, the waves on the right and left borders of zone *b* are complete time graphs of the movement of two points. These points are the intercepts of the shadow and the slit. In order to study the waves in such graphs, it is necessary to designate the time axis. In the case considered, time must be measured upward, since during the exposure the film moved down and the lowermost part of the exposed area was irradiated first. This is indicated on the diagram by the arrow *t*.

Thus, at the beginning of the exposure the left point (intersection between left shadow border and slit) was in the position q_1. A short time later it had moved laterally to the position q_2. Later it is in its mesial position, etc. If the record is turned so that the lower edge of the recorded zone is to the left and the left side of the film upward, we should have a graph on conventional coördinates in which time is measured to the left and

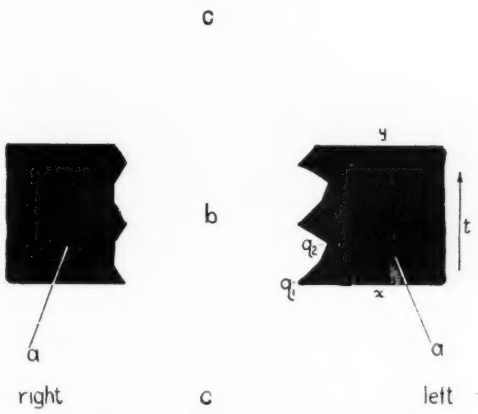


Fig. 1. A single slit-moving film kymogram (diagrammatic).

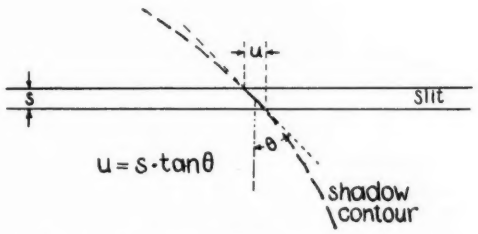


Fig. 2. Origin of obliquity unsharpness. The shadow contour crosses the slit obliquely so that a zone of width *u* is occupied by the shadow edge.

lateral displacement of the left border upward. By turning the film so that the lower edge is to the left, but the right side upward, the lateral displacement of the right border would be measured upward (time remaining to the left).

The time scale is obviously fixed by the speed of film movement. In our example, the time scale is 1.2 cm. for a second. It is the same for both the right and left borders, and points on the two curves, equidistant from the starting line (bottom), are simultaneous.

If the movement is periodic, *i.e.*, a regular repetition of similar displacements,

[3] If the slit is moved, instead of the film, the information as to shadow shape and size may be relatively complete (scanography). In such a case, however, the time axis is not straight.

we can speak of its period and its frequency.

The period is the time between two successive identical occurrences. It is equal to the distance d between successive

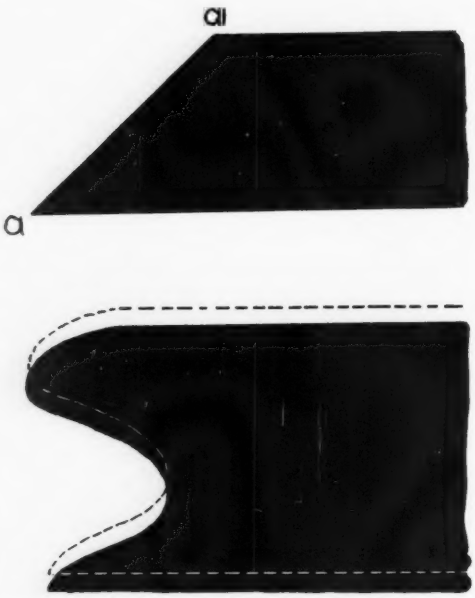


Fig. 3. (*above*). Kymogram in which the shadow edge moved with a constant velocity in a direction parallel to the slits during the exposure.
Fig. 4 (*below*). Kymogram with infinitely narrow slit, and dashed contour of kymogram of same movement, if narrow slit were displaced.

similar peaks divided by the speed of movement, *i.e.*,

$$T = \frac{d}{v}.$$

The frequency is evidently the reciprocal of this, or with obvious symbols

$$n = \frac{1}{T} = \frac{v}{d} \text{ events per second,}$$

or

$$N = \frac{60}{T} = \frac{60v}{d} \text{ events per minute.}$$

Distortion and Definition.—Since the waves are representations of the movement of points defined in relation to the shadow and the grid, they will be enlarged in the ratio of target–film to target–grid distance.[4] This enlargment refers only to the extent of displacement, not, of course, to the time axis, which is determined completely by the film speed.

The sharpness of the waves will depend in the first place upon the usual factors determining sharpness, such as focal-spot size, ratio of object–film to object–tube distance, screen grain, screen contact, etc. It will also depend in the usual manner upon the degree of contrast, so that a contrasty film will give the impression of greater sharpness.

In addition, there is a type of unsharpness which appears only in the kymogram. It may be called *obliquity unsharpness* and is produced when the border of the shadow is not perpendicular to the slit. In Figure 2, the distance u represents the width of a zone of unsharpness due to the obliquity of the shadow edge to the slit. Obviously, $u = s \tan \theta$.

A further type of unsharpness appears at the edges of the band (x and y, Fig. 1), due to the fact that since the film is moving at the start and at the end of the exposure, a zone equal in width to the slit s at both start and finish of the exposure cannot receive the full amount of radiation. Points on the film near the bottom of the slit (film moving down) at the start of the exposure, and those near the top at the end of exposure do not receive as much radiation as do those between. If the slit-bearing screen is close to the film and perfectly opaque, the width of the film receiving some radiation will be the ideal width (film velocity × exposure time) increased by the slit width s.

Consider, now, the appearance of a kymogram at the edge of a shadow, perpendicular to the slit so that there is no

[4] Note that the waves are defined in relation to the grid. Without the slits there would be no waves. The latter have no independent significance. The enlargement here given does not take into account the fact that the shadow itself is an enlarged projection of the object. From the point of view here taken, the shadow is the object the motion of which we are studying.

obliquity unsharpness, moving with a constant speed v in a direction parallel to the slit. Assume, for simplicity, that the shadow is perfect (*i.e.*, no energy reaches the film when inside the shadow). The occluding) will receive more (or less). Only points which traverse the slit without any change occurring will have either none or the full exposure; these are points inside or outside the shadow, but not near

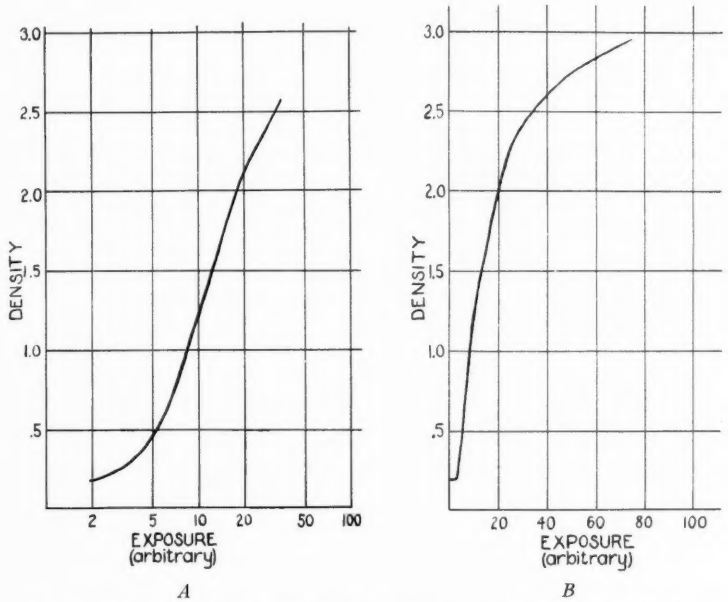


Fig. 5. Relation between density and exposure. *A*. On logarithmic scale; *B*. On linear scale. (These curves are taken from data for double-coated film in screens, kindly provided by Mr. R. B. Wilsey, of the Eastman Kodak Company.)

resulting kymogram would have the appearance indicated in Figure 3. The straight edge a, a^1 indicates a movement of uniform speed. Even if we assume all the causes of unsharpness heretofore mentioned to be inoperative, the edge a, a^1 cannot be sharp.

Perfect sharpness of this edge would imply that every point of the film received either no energy or that corresponding to an exposure for the characteristic time. Such a condition may easily be shown to be impossible. Consider a point in the film at the center of the slit at the time the shadow uncovers it (or occludes it). This point must receive an exposure of half the characteristic time. Points higher up on the film at the moment of uncovering (or the moving edge at any time. Thus, the edge representing a moving shadow must have movement unsharpness of magnitude equal to s. This represents a *time unsharpness* of magnitude s/v. No event in the kymogram can thus be timed directly with absolute accuracy. There is a time unsharpness of amount s/v which is equal to the characteristic time.

It is interesting to consider somewhat more closely the actual course of time unsharpness. Figure 4 shows a record of a particular movement which would be obtained if the slit were infinitely narrow, *i.e.*, with no movement unsharpness, and if this infinitely narrow slit is considered to be located at the bottom edge of the real slit. The dashed line indicates the

edge of the record which would be obtained if the imaginary slit were located at the upper edge of the real slit. The vertical distance between these two imaginary records is equal to the slit width. The zone between them is the region of time unsharpness in an actual record. This zone will appear somewhat like the penumbra of a shadow, shading off between the illumination of the two regions of low and high photographic density.

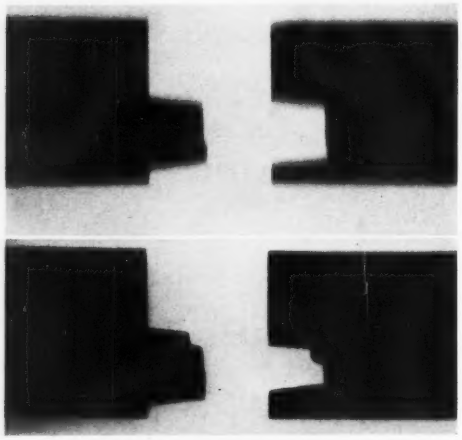


Fig. 6. Kymogram taken of an object moved as indicated. The slit width is one-fifth of the record length. Note that events on both sides, really simultaneous, do not appear to occur at the same time. This is attributable to the non-linear (logarithmic) response of the photographic material.

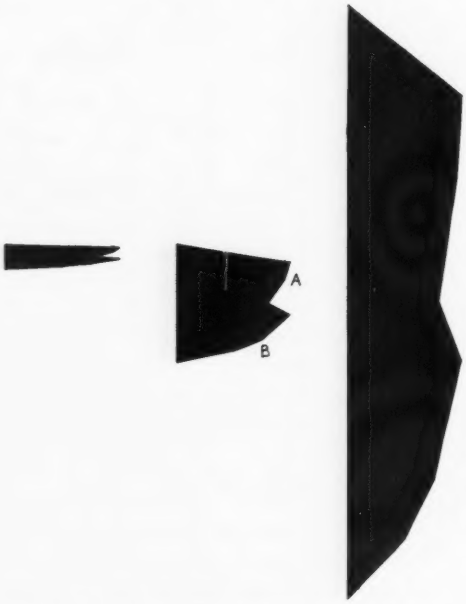


Fig. 7. The *esthetic* relation. The changes in velocity observable in the middle record at *A* and *B* are not both as clearly seen in either of the two records at right and left. The three records are identical, except for the time scales. In the middle record this is so selected that the length of the wave (time scale) is equal to its amplitude.

If the movement to be recorded is so rapid, the film speed so slow, or the slit width so great, that the zone of unsharpness is as great or greater than the width of the ideal wave (infinitely narrow slit), then the entire wave will be enclosed in a zone of unsharpness, and measurements of time or duration will become impossible. This limit on the duration of a wave, below which it cannot be recorded with any precision, is called the *resolution* of the kymogram. A rough index to this quantity is obviously the characteristic time, which is of the same order of magnitude. This difficulty cannot be overcome by magnification of the film photographically or optically. The unsharpness would be magnified together with the rest of the image. No closer time measurement could be obtained. This situation is similar to that presented by ordinary radiography, in which the unsharpness due to focal spot size does not permit the accurate delineation of detail. Enlargement cannot help put details in an image where they do not exist.[5]

This time unsharpness corresponds, in a rough way, to the effects of instrumental inertia in recording instruments. The physiologist is accustomed to indicate the limit of time accuracy of any type of recorder by stating its natural frequency or natural period. Although an instrument will respond to impulses which occupy less time than the natural period, they do so with great distortion. For this reason the natural period is usually regarded as setting a limit. An instrument is not to be depended upon for the recording of events

[5] This is generally true when the details lost are of greater size than the resolving power of the eye. In roentgenography this is usually the case.

which occupy a time smaller than the natural period.

Since there is nothing corresponding to inertia[6] in the roentgen kymograph, there can be no natural period. The resolution is nevertheless limited, so that events occupying a time smaller than the characteristic time are not properly recorded. Thus the characteristic time of a kymogram may be considered as analogous to the natural period of other types of recorders.

It is important to note that the characteristic time as a limit for the resolution obtainable is somewhat stringent. Actually, since the photographic response is logarithmic, the unsharpness zones are narrower than the slit width.

In the zone of time unsharpness (neglecting all other types of unsharpness), the exposure actually received by any point on the film is a linear function of the distance of that point from the ideal (infinitely narrow slit) position. The photographic density resulting is a logarithmic function of the exposure, indicated by the well-known photographic sensitivity curves, an example of which is shown in Figure 5-*A*.

Figure 5-*B* shows the same relation plotted on linear scales. In the time unsharpness zone, the width of which is always equal to that of the slit, the density thus varies, not linearly, but starting at the side of higher density, the density varies slightly at first and then more sharply, thus giving the appearance of a narrower unsharpness zone, and a sharper transition from the unsharp zone to the region of low density. If the density of the darker side of the zone is very low, the low density cut-off (background fog) will narrow the unsharpness zone on the low density side.

The effect just discussed thus tends to narrow the zone of unsharpness somewhat, and to produce an apparent sharper edge. This apparent sharp edge is, however, not at its theoretical location but displaced, generally toward the side of lower photographic density. Figure 6 shows two kymograms of an opaque object which, during the course of the exposure, was given a single rapid to-and-fro movement. The slit width was 4.5 mm. Events on either side of the strip are obviously simultaneous, yet the waves on either side do not appear so. The difference is accounted for by the effect described.

The obliquity unsharpness discussed above enters also to produce additional time unsharpness. The obliquity unsharpness represents a zone of width $s \tan \theta$, measured parallel to the slit. If the movement of the shadow edge has a velocity V, the edge of the wave will make an angle, ϕ, with the normal to the slit, where $\tan \phi = V/v$ (v = film velocity) and the time unsharpness due to this cause will be given by

$$\frac{u}{v \tan \phi} = \frac{u}{V}$$

or

$$\frac{s \tan \theta}{V}.$$

A true measurement of a wave on the kymogram is thus in doubt by an amount equivalent approximately to the characteristic time, increased by a variable amount dependent upon obliquity, the velocity of shadow movement (parallel to slit), and the actual slit width. A partial correction may be made in certain cases, if account is taken of the unsharpness zones and their structure.

Moving Slit.—The moving film method gives a result from which conclusions may be drawn as to the movement of the portion of the shadow intercepted by the slit. The moving slit method is not susceptible to this simple analysis. Since the slit is not stationary, the record is that of the variations in the intercept of the shadow on a varying line—the moving slit line.

Such records are more complicated, yielding information not only as to movement, but also as to shape of the shadow. In general, the waves due to movement

[6] The time lag of intensifying screens may come in this category, but has not been found to be of significance in clinical kymography.

will be superposed upon the shadow contour, and not be true time graphs of the motion.

The factors influencing unsharpness, etc., are essentially the same for the moving grid as for the moving film. For accurate time analysis, the moving film method is definitely preferable. The further discussion in this paper will be limited to the moving film method.

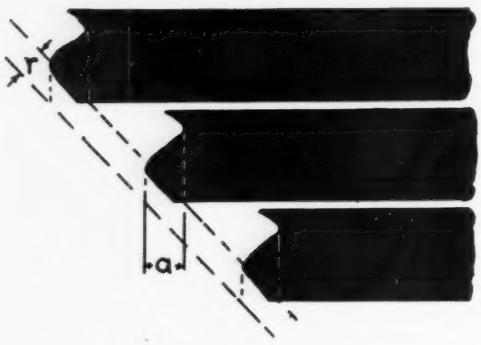


Fig. 8. *Real* and *apparent* amplitude, *a* is the *apparent* amplitude and *r* the *real* amplitude. The diagonal lines are drawn through the projection of the peaks on the bottom edges of the bands.

Density Waves.—In the kymographic exposure at the basis of the discussion up to this point, it was supposed that the technic was selected so as to produce a very contrasty result. The shadow region in Figure 1 was to be imagined completely unexposed.

If the technic were so selected that the shadow region is penetrated, other features appear on the kymogram. In addition to the contour waves, there will appear bands of varying illumination in the shadow These correspond to the varying density of the object casting the shadow, or, more strictly, to varying intensity of the beam coming through the slit. Such variations are most commonly due to variation in width of the section of the object cut by the plane containing the slit and the tube focus. If the width of this section measured along any ray varies with time, then that ray will produce a varying illumination of the film.

It is often difficult to evaluate such films with the unaided eye, since the eye is insensitive even to relatively large differences in density, unless those differences are separated by a sharp edge. In kymograms, the density waves may be barely visible, or not even noticeable, and still represent considerable change in density. This will especially be the case if the changes are not very rapid, relative to the time scale (v) of the record.

The density waves can be studied more accurately by use of a recording densitometer. The densitometer is a device in which a narrow pencil of light is passed through the film. This light beam acts upon a photo-electric surface. The photo-electric current is then used to operate a recorder to produce a record of the intensity of the transmitted light. As the film is moved, the recording surface of the instrument is also moved proportionately, so that a record of the relative transparency of the film may be made along any line. If the line is chosen parallel to the time axis, the instrument converts the density wave into an actual time curve which can be studied to better advantage.

The density waves are representative of the changes in intensity of the x-ray beam striking the film within the shadow. Such changes are frequently due to changes in dimensions of the shadow-casting structure, or to changes in its position by virtue of which different thicknesses come into the focus-slit plane.

Thus the single-slit kymogram with density waves gives information with regard to two dimensions. The information is scanty, however, since many possible types of movement may produce the same kind of record.

The density waves, even when recorded by an accurate (narrow beam) densitometer, suffer from defects similar to those which occur in the contour waves. The existence of a finite characteristic time introduces an indefiniteness in time meas-

urements, similar to those discussed above for the contour waves.

These defects cause an error in time measurement. While, with the densitometer, there never need be any doubt as to the actual value of the illumination at any point of the film (comparable to the doubt as to the actual position of the edge of the contour wave), nevertheless, the course of the density variations are not true reflections of events. The waves recorded by the densitometer show a slurring of sharp changes due to slit width. There is also a time shift due to the slit width.

Technical Factors.—The length of record is limited by the available length of film and by the total quantity of x-rays which may practically be used. If the length of record is denoted by l, the duration by T, and the film speed by v,

$$T = \frac{l}{v}.$$

The characteristic time τ is given by s/v so that

$$T = \frac{l\tau}{s}.$$

Experience has shown that, in general, the best value of v would be one for which the waves produced have a wave length of the same order of magnitude as the amplitude. This point is well illustrated in Figure 7. This condition, while by no means an absolute requirement, if fulfilled, provides records of easy legibility.[7] If a is the amplitude of the expected waves and f their frequency, this means that

$$v = af.$$

This relation may be called the *esthetic relation*, and can rarely in practice be fulfilled for more than one wave at a time. The condition is applied for the waves of greatest interest.

The duration of the record T must be great enough to depict the entire process. Hence, if $T = N/f$, it is insured that N complete cycles will appear on the record.

The value of T determines the power which can be applied to the x-ray tube, since for every tube there is a maximum time for which any amount of power may be applied. The power is proportional to kv.p. × ma. Hence, T determines this product. The part radiographed, as in conventional radiography, determines the kv.p. to be used and the ma.-sec. for the characteristic time. The ratio of kv.p. × ma.-sec. as determined, to the power, determined from T, gives the characteristic time τ which must be used. From the probable value of a, v may be determined with the help of the esthetic relation: s and l follow from the relations above.

The process may be demonstrated by considering several practical cases.

(1) *The Heart.*—Its frequency may be taken approximately as one cycle per second, and amplitude (over the ventricle) at 1 cm. If it is desired to depict one complete cycle, $T = 1$ second. For a particular tube, operating conservatively, 10,000 kv.p. × ma. is the power capacity for one second. At 30-inch distance, a satisfactory conventional roentgenogram of the heart requires 70 kv.p. and 3 ma.-sec. a product of 210 kv.p. × ma. The characteristic time is thus fixed at 210/10,000 = 0.02 second. From the esthetic relation $v = 1$ cm./sec. Hence $l = 1$ cm. and $s = 0.02$ cm.

(2) *The Contrast-filled Stomach.*—The frequency of movement may be taken as $^1/_{30}$ (*i.e.*, 30 seconds for a cycle) and the

[7] This requirement may be justified mathematically. It can be shown that small, sudden changes of velocity, which record as breaks in the kymographic wave, will be most clearly evident on a portion of a wave which makes a 45° angle with the slit line. The proof of this point is as follows: Let V_1 and V_2 be the velocity just prior to and just after the break. The angles with the normal to the slit line of the recorded edges for these velocities are, respectively, arctan V_1/v and arctan V_2/v (v = film velocity). The angular difference, or the sharpness of the break, is given by the difference between these angles, or arctan $(V_2 - V_1)\,(v/(v^2 + V_1V_2))$. Since V_1 and V_2 are assumed nearly alike, this expression reduces to arctan $(V_2 - V_1)(v/(v^2 + V^2))$ (dropping the subscript in the denominator). This quantity is a maximum when $v = V$ or $\theta = 45°$. Obviously, this condition cannot be met for all parts of a wave, but if the esthetic requirement is fulfilled, a large portion of the wave will be nearly at this angle

amplitude as about one centimeter. Hence, for one cycle, $T = 30$ seconds. A suitable tube has a capacity of 3,500 kv.p. × ma. for this time. A good conventional

Fig. 9-*A*. Fig. 9-*B*.

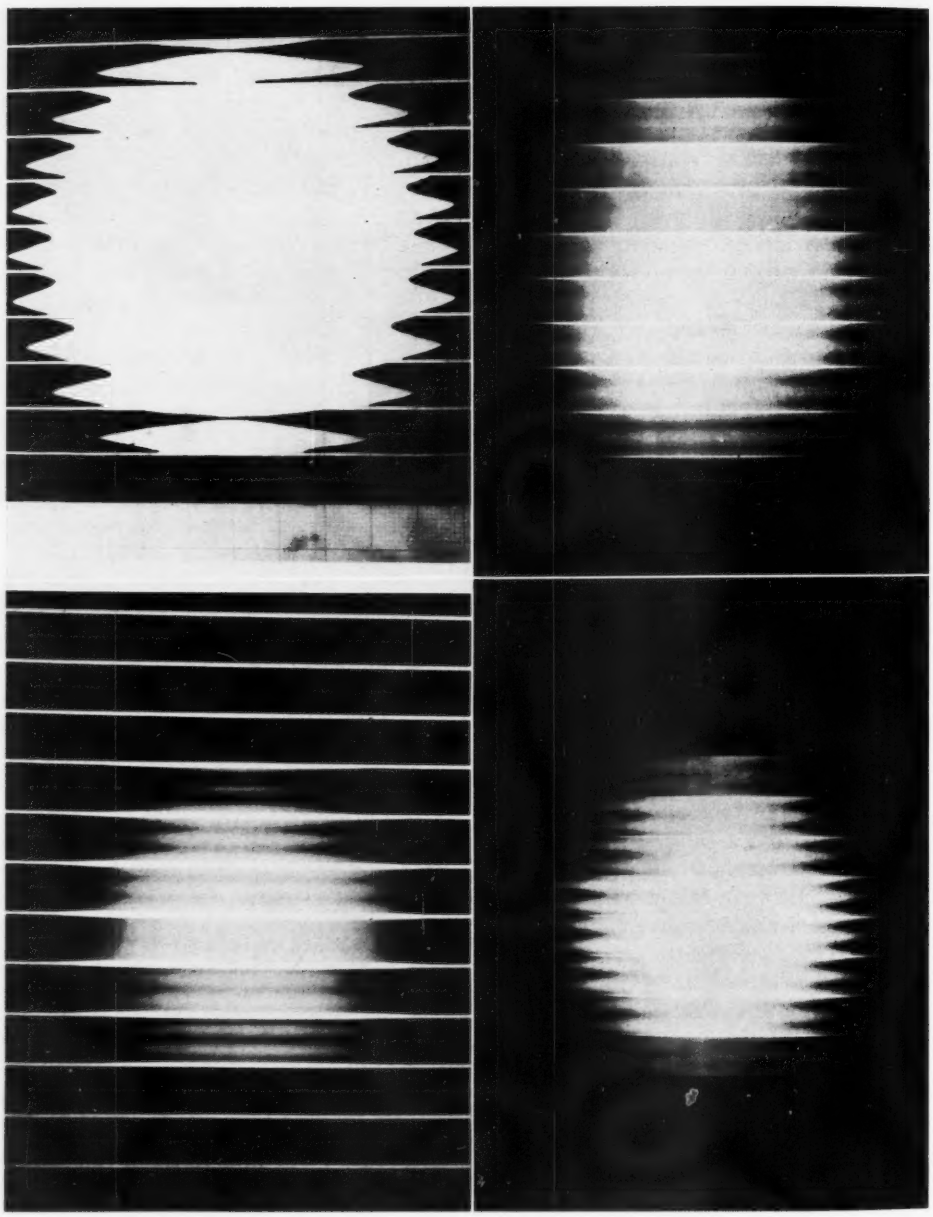


Fig. 10. Fig. 11.

Fig. 9. Kymograms of a rhythmically expanding and contracting sphere. *A*. Computed kymogram for a sphere changing its radius rhythmically (Case 1); *B*. Kymogram of a water-filled balloon oscillating along a line perpendicular to film (Case 2).

Fig. 10. Kymogram of a filled balloon oscillating in a direction perpendicular to the slits, but parallel to the film (Case 3). Note the phase variations.

Fig. 11. Kymogram of a filled balloon oscillating in a direction parallel to slits (Case 4).

radiograph of the stomach at 30 inches requires about 20 ma.-sec. at 80 kv.p., or 1,600 kv.p. × ma.-sec. The characteristic time is thus limited to 1,600/350 = 0.5 second. The esthetic relation gives v = 1/30 cm./sec. so that l = 1 cm. and $s = \tau/v$ = 0.017 cm.

The slit width found for both these cases is narrow, compared to the thickness of a reasonable lead screen. If the screen were made of lead 1 mm. thick, these slits would have a scatter clean-up action corresponding to a Bucky ratio of 5:1. Such a strong clean-up action would require additional exposure. This may be accomplished by increasing the slit width (and characteristic time). Thus, for the chest, with such clean-up action, we may estimate roughly that twice the power becomes necessary, so that instead of 210 kv.p. × ma.-sec., 420 are necessary. All quantities then remain the same, except for a doubling of slit width. A more accurate analysis, including in the formulæ the effect of clean-up, is not warranted as a practical matter.

Slit Width.—If we overlook the esthetic requirement, which obviously must be of secondary importance, a given characteristic time may be attained with any slit width, if only $s = \tau/v$. Is there an optimum slit width? A wide slit has the advantage that the time unsharpness due to the slit is large compared to that due to factors not associated with the grid. It has the disadvantages that it introduces obliquity unsharpness. Evidently, then, it would be best to make the slit wider than the unsharpness due to other factors, but narrow enough to keep obliquity unsharpness at a low value. A slit width of about one-half millimeter seems, in most cases, to be large enough to make unimportant the effect of other factors, and, at the same time, is small enough to make the effects of obliquity unsharpness for reasonable obliquities negligible, compared to those due to the characteristic time.

Multiple Slits.—Many methods of multiple-slit kymography have been proposed. All of them are essentially similar, in that the slit-bearing screen carries a multiplicity of slits, and all the individual records are made simultaneously on the same film. They differ principally in the arrangement of the slits. We shall discuss some of these methods, with reference only to the moving film procedures.

Parallel and Equidistant Slits.—This method was originated by Katzman, in 1928, developed in Europe principally by Stumpf, and later in this country by Hirsch and the author, among others. It is the most popular of all methods proposed and therefore warrants a detailed discussion.

In this method, the slits are arranged parallel and equidistant to each other, forming a grid. The movement of the film (or grid), during the exposure, covers a distance slightly short of that between slits. Thus each slit produces its kymogram, and, since the length of the record is less than the distance between slits, there is no overlapping of the records.

For the study of the heart and gastro-intestinal tract, approximately the same slit width and length of record is necessary for the fulfillment of the essential conditions, and the esthetic relation. A length of record of about one centimeter and a slit width of 0.04 cm. satisfies the conditions in both cases reasonably well. The standard grid was, therefore, adopted, having slits 1.2 cm. apart and 0.4 mm. wide. This provides room without overlapping, for esthetic records of either heart or gastro-intestinal tract, showing a complete cycle. The mechanical difference between the arrangements in the two cases is the velocity of movement. For the heart this is about one centimeter per second; for the gastro-intestinal tract, about one centimeter in 30 seconds.

The discussion of the sharpness and definition of the waves in the single-slit kymogram is fully applicable to the individual kymogram of the multiple-slit record. Each of the individual records has been called "band" since they appear as illuminated bands across the film.

Fig. 12. Fig. 13.

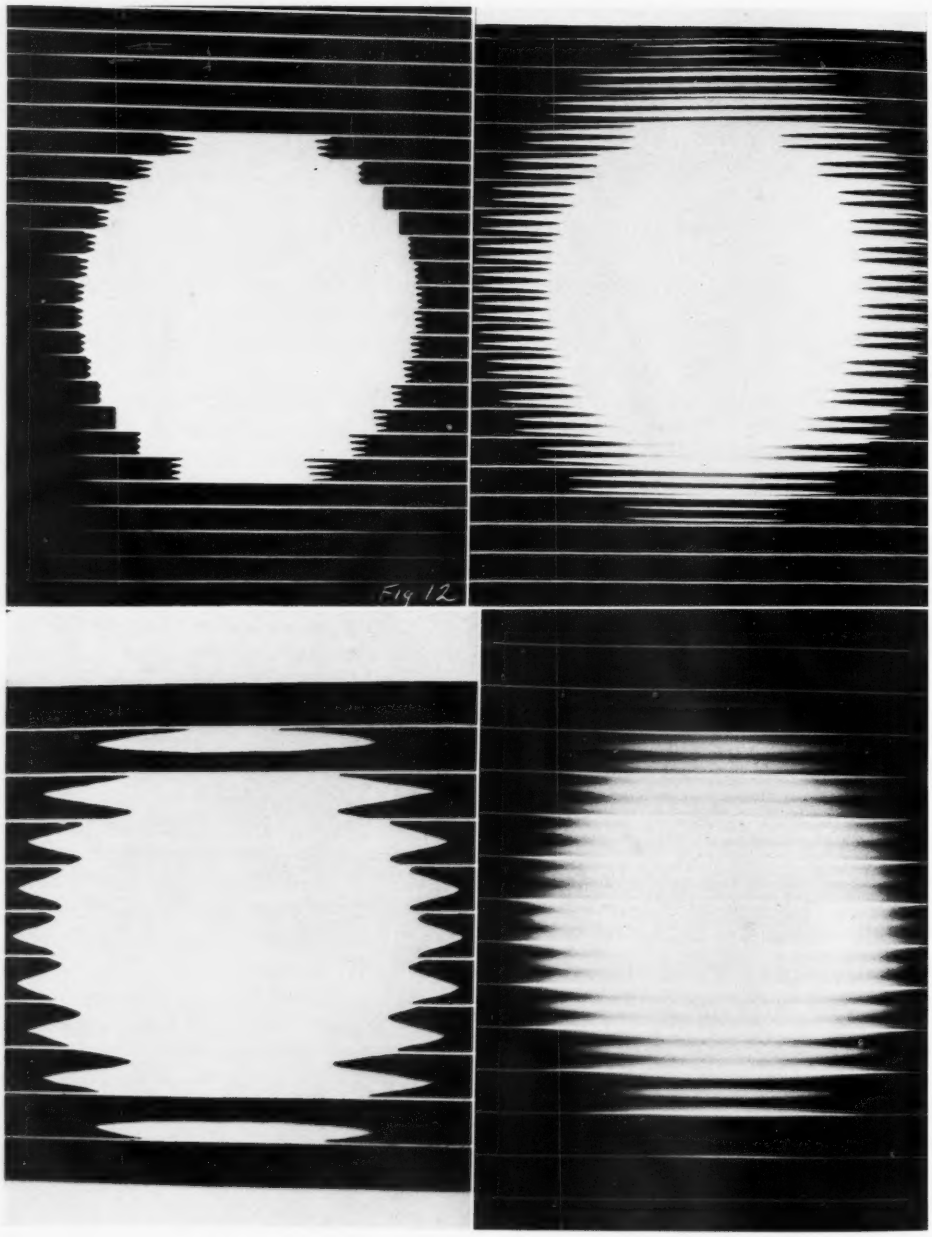


Fig. 14-*A*. Fig. 14-*B*.

Fig. 12. Kymogram of a circular shadow oscillating at any angle to the slit (approximately 45° from upper left to lower right, Case 5).

Fig. 13. Kymogram of a circular shadow rotating about an axis not through its center (Case 6).

Fig. 14. Kymogram of a spherical object, with rhythmic variations of radius combined with oscillation about a line parallel to the film but perpendicular to the slits (Case 6). *A*. Calculated for the case in which the two oscillations are 90° out of phase; *B*. A water-filled spherical balloon performing such oscillations. The short black lines near the edges are all simultaneous. Note the phase shift.

The multiple-slit record yields more information than that of a single slit. All of the individual bands have the same time scale, hence it is possible to correlate the waves in various bands.

In the study of the kymogram, the matter of time relationship is very important. Kymographic waves are due to the movement of the shadow edge. If, as is usually the case, the film moves downward, the time flow on the record is upward. A limb of a wave which represents a lateral movement of the shadow edge may be called a lateral limb. Similarly, a limb which represents a mesial movement may be called a mesial limb. A lateral limb extends from a low (early) mesial position to a higher (later) lateral position. The point at which a lateral limb (lower, earlier) meets a mesial limb (higher, later) is called a lateral peak. The point at which a mesial limb (lower, earlier) meets a lateral limb (higher, later) is called a mesial peak.

The density variation in the shadow may be brought into a similar nomenclature. A zone of increased illumination, corresponding to a time at which the width of the section of the structure in the slit–focus plane is at a minimum, may be said to be a *contracted density peak*. A zone of decreased illumination similarly may be said to be an *expanded density peak*. In those times at which the illumination increases in the direction of time flow, there is a contracting variation of density, while when the illumination decreases, there is an expanding variation of density.

The time relationships between the various waves of a single kymogram are often expressed by the term *phase*. Thus, if two contour waves are simultaneously in their lateral and mesial limbs, the lateral and mesial peaks being at the same distance from the lower edge (start) of their respective bands, they are said to be in phase. A contour wave and a density wave are in phase if the lateral and mesial peaks of the former and the expanded and contracted peaks of the latter are, respectively, simultaneous.

Two waves are completely out of phase if the mesial (or contracted) and lateral (or expanded) peaks of one are simultaneous, respectively, with the lateral (or expanded) and the mesial (or contracted) peaks of the other.

If the peaks are not simultaneous, the waves are said to be out of phase by an amount often expressed directly in time, in particularly simple cases expressed as a fraction of the complete cycle (time between successive homologous peaks). The amplitude of a contour wave is the distance, measured in the direction of the slit, between lateral and mesial peaks. In the case of density waves, the amplitude represents the difference in illumination between an expanded and a contracted peak. It is measurable only with the densitometer and then in arbitrary units.

If the density waves near a contour wave are in phase, and if the amplitude of the density waves is great, the increased illumination simultaneous with the mesial peak may reach a level so high that the contrast at the shadow edge may be lost. The valley or mesial peak of the contour waves in such a case diffuses into the illuminated band of the density wave, and measurement of the amplitude of the contour wave may be impractical.

"Real" and "Apparent" Amplitude.—In contour waves, a distinction has sometimes been made between the *real amplitude* of the movement and the amplitude of the waves, which has been called the *apparent amplitude*. Figure 8 shows this distinction. The real amplitude, so defined, is the amplitude of movement of the shadow edge measured in a direction at right-angles to the edge. It has no more reality than the apparent amplitude, except in certain special cases. It is the quantity perceived during fluoroscopy of a moving structure.

Movement and Waves.—In general, as we have seen, it is impossible from the kymogram to draw unique conclusions as to the shape and the movement of a structure. Often we must rest content with an inductive study based on a large series of films taken on normal and abnormal individuals.

In a limited number of cases, the problem of interpretation is narrowed to a selection between certain anatomically and physiologically possible alternatives. Under such conditions, an interpretation may occasionally be made deductively. Such deductions may be simplified and clarified by a discussion of the kymograms which are produced with certain simple mechanical structures and movements. For this purpose a study was made of such situations. In the real application, conditions will rarely be as simple as the cases here presented. Nevertheless, it appears of value to present these cases with a discussion of the associated kymograms.

The consideration of these cases will show the difficulty of concluding from the kymogram as to the actual movement. This situation is characteristic of radiography in general. It is impossible to conclude from a radiograph as to the size and shape of a structure. The radiograph cannot uniquely determine the structure producing it. The kymogram, as well, cannot uniquely determine the movement. In clinical roentgenography, the film is used to determine the structure in the light of anatomic possibilities. In the same way, the kymogram must be used to determine movement and shape in the light of anatomic and physiologic possibilities.

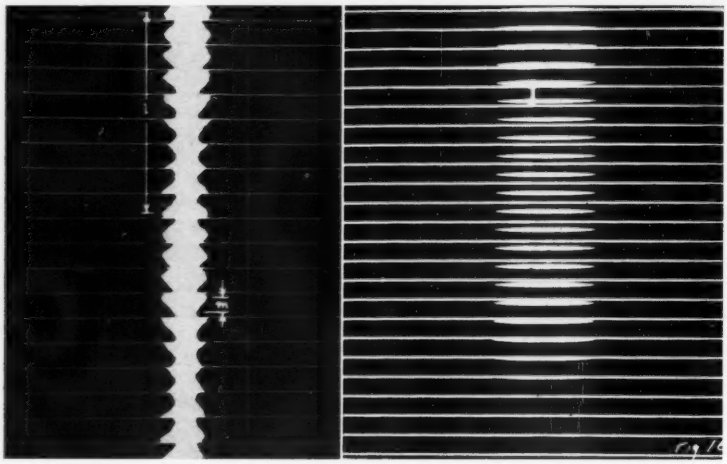


Fig. 15. Fig. 16.

Fig. 15. Peristaltic wave. l is the distance between bands showing same phase. This is the length of the wave. $\frac{m}{v}$ is the time for a half period; the time for the full period is $\frac{2m}{v}$ and the velocity of the peristaltic wave is $\frac{lv}{2m}$ (Case 7).

Fig. 16. Kymogram of a sphere moving uniformly in a direction parallel to the film and perpendicular to the slits.

Case 1. A sphere, center fixed in space, but expanding and contracting rhythmically.

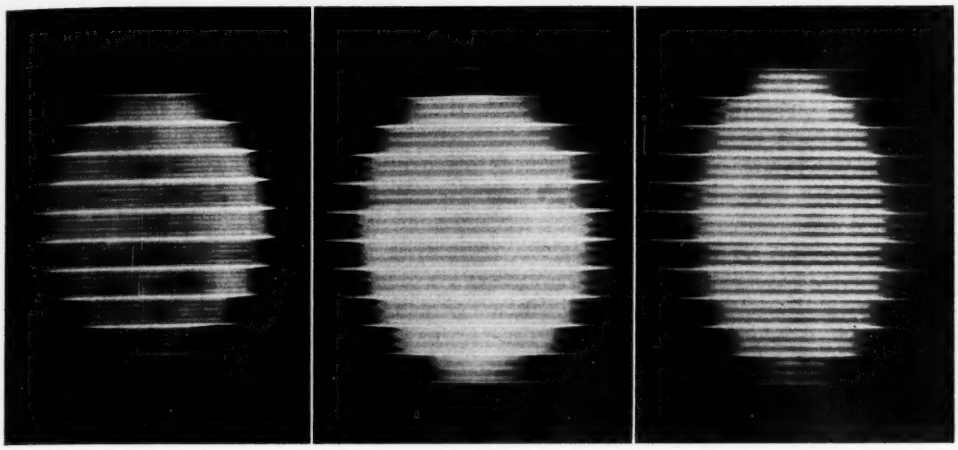
The waves throughout (Fig. 9-*A*), both contour and density, are in phase. The amplitudes of the contour waves show a progressive change along each contour, being smallest in the band approximately at the center of the shadow. The real amplitude is constant over the whole border, and is actually equal to the amplitude of the oscillation (except for correction due to target–object–film projection errors).

Case 2. A rigid sphere oscillating in a direction along the central ray (centric projection).

The shadow in this case expands and

contracts rhythmically as in Case 1. The contour waves (Fig. 9-*B*) are thus all in phase and vary in amplitude as in Case 1. The density waves will also be similar.

result is due to the movement of the entire shadow in a direction parallel to the slits, and without rotation, the waves on one side must be all in phase, while a com-



A *B* *C*

Fig. 17. Kymogram of a disc-shaped object performing rotatory oscillation about a diametral axis parallel to the film and perpendicular to the slits (Case 9). *A*, *B*, and *C* are correlated with *A*, *B*, and *C* of Figure 18.

Case 3. A rigid sphere oscillating along a direction perpendicular to the slits, but parallel to the film.

The kymogram (Fig. 10) is divisible by a diameter parallel to the slits into two portions. In each half, the waves of all types are in phase. The waves in one half are completely out of phase with those in the other half. The real amplitude varies from band to band, and evidently is of no great significance.

Case 4. A rigid sphere oscillating along a direction parallel to the slits.

The kymogram (Fig. 11) may be divided by a diameter perpendicular to the slits in two portions. The waves (both contour and density) in each half are in phase, the contour waves all of the same amplitude. The waves of one half are completely out of phase with those of the other half, but of the same amplitude. The real amplitude varies, and has little significance. A similar kymogram is produced no matter what the shape of the structure. Since the plete reversal of phase occurs from side to side.

Case 5. A rigid sphere oscillating along a line parallel to the film but at an angle to the slits. This movement may be considered as a combination of Case 3 and Case 4, the movements occurring simultaneously and of relative amplitude depending on the angle.

The kymogram (Fig. 12) shows three distinct regions, divided by lines parallel to the slits. In each of the regions, top and bottom, all the waves are in phase, but all the waves of the bottom are out of phase with those of the top region. In the middle section, the waves are out of phase on each side. The amplitude variations are clearly indicated in the figure.

Case 6. A rigid sphere moving in such a manner as to combine two rhythmic movements with varying relative amplitude, and out of phase. Two harmonic movements combine to produce a harmonic wave of phase dependent on the phase dif-

ference between the two components and their relative amplitudes.

The resulting kymogram in a case of this type must, therefore, show waves of varying phase along a contour. There is a simple mechanical movement, not probable physiologically, which illustrates this case. It is the rotation of a sphere about an axis perpendicular to the film but not passing through the center of the sphere. This is a combination, out of phase, of Cases 3 and 4. The kymogram (Fig. 13) shows variations in phase around the contour, as is to be expected.

Of greater importance, physiologically, are movements corresponding to combinations of Cases 1 and 4, out of phase. Such a movement would be an expansile pulsation combined with a side swing. The results should also show phase differences from band to band.

Another physiologically possible movement, which must show a phase shift, is a combination of an oscillation perpendicular to the slits but parallel to the film with an expansile pulsation out of phase with it. This is a combination of Cases 1 and 3. Figure 14 shows kymograms of this type of movement. This may be the explanation for the frequently observed phase shift along the border of the left ventricle.

This case is important because phase shifts have been thought by many to be due solely to a peristaltic movement.

Case 7. A cylindrical structure disposed with its axis parallel to the film and perpendicular to the slits, traversed by a regular series of peristaltic waves.

All the waves in each band are in phase (Fig. 15). The waves in various bands are out of phase by an amount corresponding to the differing times at which any peristaltic wave reaches the level of the various slits. From this time difference, together with the actual distance between slits, it is possible to calculate the velocity of the peristaltic wave. The frequency of the peristaltic wave is obviously the same as the frequency of the recorded waves. The length of a peristaltic wave is the distance from one band to the next showing the same phase. The velocity is equal to the product of the length by the frequency.

Case 8. An important type of movement is illustrated in the kymogram of Figure 16. The structure in this case was a sphere moving uniformly in a direction parallel to the film and perpendicular to the slits. In each band the shadow occupies a position (either top or bottom of the shadow) corresponding to the time at which the shadow of the sphere entered (bottom of shadow) or left (top of shadow) the slit. The velocity of movement is evidently calculable from the time difference measurable in the kymogram. This case is representative of the movement encountered in an important physiologic process, deglutition.

Case 9. A disc-shaped object oscillating about a long diameter which is parallel to the film and perpendicular to the slits, as an axis.

The kymograms produced in this case are shown in Fig. 17-*A*, *B*, and *C*. The three records were made with the same disc, oscillating with approximately the same amplitude and frequency of oscillation. The film speed was the same in all three. The marked differences in the record are the result of oscillation about different mean positions. The matter is illustrated in Figure 18 for parallel rays. The records were made with divergent rays, which accounts for the deviation from symmetry of the waves on either side. Near the edges the density waves are in phase with the contour waves, while within the shadow they are completely out of phase. The density waves are the result of changing obliquity.

Case 10. A disc-shaped object, distorted into a skewed, screw-like structure, oscillating about a major diameter.

The kymogram (Fig. 19) shows waves of all types (*A*, *B*, and *C* of Fig. 18), since now various parts of the disc have differing mean position. The density waves are again in phase with the contour waves near the edge, but completely out of phase inside the shadow.

A careful measurement of the original

record also shows a phase shift of certain of the homologous peaks, namely, those corresponding to extreme position 2 in Figure 18-*A* and *B*. This shift is another result of the screw-like shape.

This case is noteworthy since it represents a rigid structure performing simple rhythmic movement, yet showing on the kymogram an assortment of frequencies, notched waves, and phase variations.

All of the kymograms illustrating the various cases given are different in some essential respect. Thus, the kymogram would be sufficient to determine to which case of an unknown type of movement it belongs, provided it belongs to one of the enumerated cases. To make such a decision, all the waves on all contours, as well as the density waves, would, in general, be necessary.

In the clinical application of kymography, the situation is in some ways more difficult, in others simpler. The problem is more difficult because it is rarely possible to record waves over the entire contour of structures in the living; nor is it always feasible to record all the density waves. In addition, the physiologic movements and anatomic shapes are not generally of the simple types enumerated. On the other hand, the shapes of structures are usually well known or independently determinable and the movements are, in general, limited to a small number of physiological possibilities. Thus, in spite of the complexity of the problem, valuable conclusions may frequently be reached.

In many applications this deductive method of approach is not as profitable as in the inductive method. The study of large numbers of normal and pathologic cases yields criteria which permit the evaluation of the kymogram in individual cases. Such studies have been made and are now being continued in many laboratories.

It is interesting to compare the possibilities of kymography with two other procedures, fluoroscopy and cineradiography. Prior to the development of the kymographic method, fluoroscopy was the

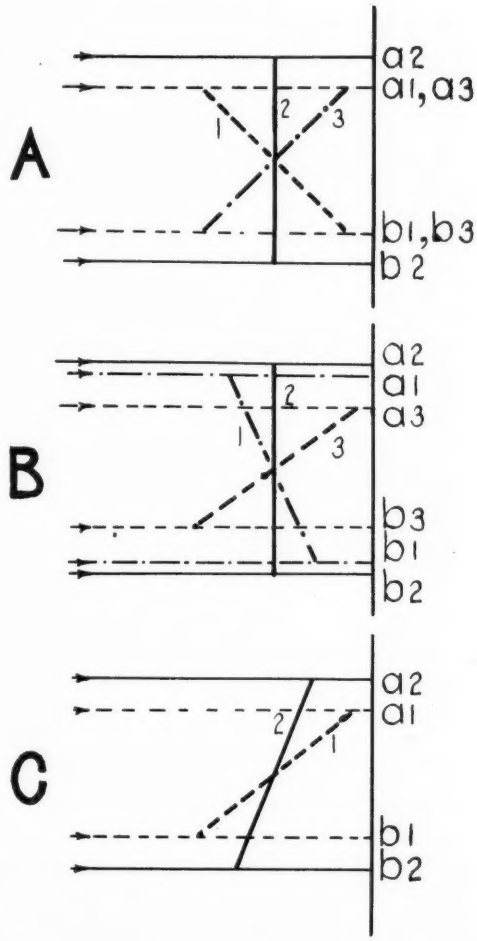


Fig. 18. The genesis of the waves produced by a disc-shaped object oscillating about a diameter disposed parallel to the film and perpendicular to the slits (for parallel rays). The vertical lines at the right represent the film. Points a_1, b_1, a_2, b_2, etc., represent the edge of the shadow produced by the object when in positions 1, 2, etc. Lines with arrows represent rays. *A*. The disc oscillates about a mean position parallel to the film. The diagram shows a section of the disc in the focus–slit plane. The disc oscillates through position 1—2—3—2—1, etc. The shadow expands and contracts for each swing of the disc, so that during a complete oscillation, two peaks are produced on the kymogram. These peaks are of equal amplitude for parallel rays. *B*. Same as *A*, except that mean position is at an angle to film. A similar result is obtained, except that one extreme position of the shadow a_1, b_1, is of different length than the fully contracted shadow, a_3, b_3. *C*. Same as *A* and *B*, except that mean position is at a still greater angle. Here there is only one oscillation of the shadow edge for each oscillation of the disc.

preferred means for the study of the movement of the internal structures. Yet fluoroscopy suffers from precisely the same limitation as kymography. On the fluoroscopic screen only the shadow is visible. Movement of the shadow cannot be correlated with the movement of the structure except in relation to known anatomic and physiologic possibilities.[8] The kymograph (in several projections if desired) yields all the information obtainable from the fluoroscope in a more precise, complete, and permanent form. Thus, for example, a fluoroscopic examination of the heart may show an unusually pronounced pulsation of the aortic shadow. The kymogram will indicate not only the amplitude and form of this pulsation but also its time relationships with the pulsations of the other structures.

The shadow contours at every instant of the cycle are easily determined from the kymogram so that the latter also provides, in a convenient form and by a simple and inexpensive procedure, all the information which could be obtained by means of cineradiography.

Instantaneous Contours.—The shadow at any instant may be constructed from the kymogram. In order that not only shape, but also position, may be properly reproduced, the position of the edges of the shadow at various times must be projected in every band to corresponding standard lines. A convenient standard line in each band is given by its lower edge.

The kymogram (Fig. 20) is that of a rubber balloon filled with water, which, during the exposure, was made to pulsate by the periodic injection and withdrawal of water by means of a syringe. The contours at the times of maximum and minimum diameter in band *X* were constructed. It is clear how the balloon changed its shape and position with the addition and withdrawal of water.

Figure 21 shows a similar situation with a smaller, stiffer balloon. Note that now the fall in position is not so marked. The situation approximates that of the uniformly expanding or contracting sphere (Case 1, Fig. 9).

Cignolini Method.—In this arrangement the slits are relatively short, and mechani-

[8] The systems of cams and oscillating structures used in the demonstration of fluoroscopy by Levene, at the Fifth International Congress of Radiology, Chicago, 1937 (exhibit No. 44), illustrated this point well.

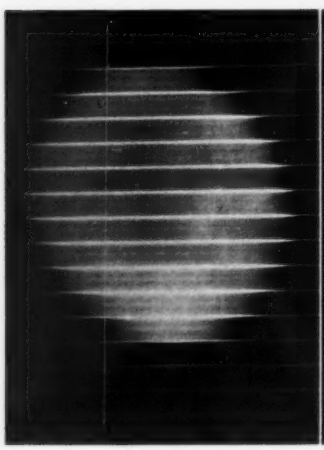


Fig. 19.

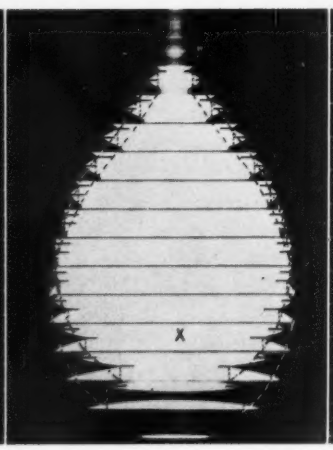


Fig. 20.

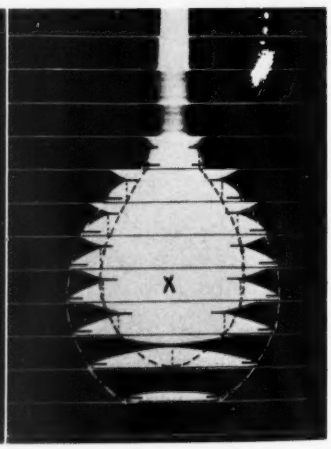


Fig. 21.

Fig. 19. Rotatory oscillation of a skewed disc (screw).
Fig. 20. Kymogram of a pulsating balloon. The instantaneous contours are drawn for the instants of the lateral and mesial peaks in band *X*. The contours are produced by connecting the projection of the synchronous points in each band on the bottom edge of the band.
Fig. 21. Same as Figure 20, for a smaller and stiffer balloon.

cally arranged so that they may be disposed in a great variety of ways. The slits are all parallel but at various levels. The length of the records of movement (the individual single-slit kymogram) is limited only by the length of film available and the total practicable time of exposure.

In the application of this method by Cignolini, a slit width of 2 mm. was used. The speed of film was 5 cm. per sec., so that the characteristic time was 0.04 second. For the heart, the esthetic requirement is not at all fulfilled. In regions of relatively large obliquity, the unsharpness due to this cause is large. This method has not become very popular, chiefly because of the inconvenience of placing the slits, which must be done under fluoroscopic control. In addition, Cignolini arranged matters so that the entire length of his film (40 cm.) was exposed for each slit. To do this when the slits are at different levels requires 50 per cent more exposure time than that given by l/v. Except for the study of arrhythmias, there appears to be no advantage in the long record.

Morelli Method.—A method using multiple slits, which also has not become very popular, is that developed in South America by Morelli. The slits in that system are arranged radially, and the film (or grid) rotates during the exposure. The extent of rotation is limited to prevent overlapping. Considerations of definition and detail are essentially unchanged since the slit width increases radially so as to maintain a nearly constant characteristic time. The grid described in Morelli's monograph had 18 slits, each approximately 0.5° in angular width, separated by opaque sectors of angular width about 19.5°. The supposed advantage of the method is principally that for the heart the slits are more nearly perpendicular to the shadow border, at least over the ventricle, and hence, *real* and *apparent* amplitudes are nearly alike. Whether this advantage outweighs some of the obvious disadvantages must be determined by experience. Some of these disadvantages are:

(1) Simultaneity in time, and time measurements in general, are more difficult of determination because the time scale depends on distance from the center of rotation.

(2) An error is introduced by any lack of alignment between the radial origin of the slits and the center of rotation.

(3) In the case of the heart, for which the method has been primarily developed, great obliquity errors in vascular shadows must occur if the center of rotation is at the approximate center of the heart.

(4) Standardized technic will be difficult, since it requires special procedures to insure that the center of rotation is always at the same place, even in the same individual.

SUMMARY

(1) The physical principles of slit kymography are discussed, with emphasis upon the factors influencing the accuracy of time measurements. This is discussed in terms of the so-called *characteristic time.*

(2) The condition for records of maximum readability is given and called the *esthetic* relation.

(3) A number of types of movement are studied with the multiple, parallel, and equidistant slits.

(4) The Cignolini and Morelli methods are discussed briefly.

(5) An explanation is offered for the frequently observed phase shift along the cardiac contour. The explanation does not involve peristalsis or screw-like movement, but depends on the assumption that the movement of the heart is a combination of a radial pulsation and an oscillation, these movements being out of phase.

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Editor's Note.—Will secretaries of societies please cooperate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

CALIFORNIA

California Medical Association, Section on Radiology.—Chairman, Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles; *Secretary,* Carl D. Benninghoven, M.D., 95 S. El Camino Real, San Mateo.

Los Angeles County Medical Association, Radiological Section.—President, E. N. Liljedahl, M.D., 1322 North Vermont Ave., Los Angeles; *Vice-president,* M. L. Pindell, M.D., 678 South Ferris Ave.; *Secretary,* Wilbur Bailey, M.D., 2007 Wilshire Blvd.; *Treasurer,* Henry Snure, M.D., 1414 South Hope Street. Meets every second Wednesday of each month at County Society Building.

Pacific Roentgen Club.—Chairman, Karl M. Bonoff, M.D., Los Angeles; *Members of Executive Committee,* I. S. Ingber, M.D., A. C. Siefert, M.D., D. R. MacColl, M.D.; *Secretary-Treasurer,* L. Henry Garland, M.D., 450 Sutter St., San Francisco. Executive Committee meets quarterly; Club meets annually during annual session of the California Medical Association.

San Francisco Radiological Society.—Secretary, L. H. Garland, M.D., 450 Sutter Street. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

COLORADO

Denver Radiological Club.—President, F. B. Stephenson, M.D., 452 Metropolitan Bldg.; *Vice-president,* K. D. A. Allen, M.D., 452 Metropolitan Bldg.; *Secretary,* E. A. Schmidt, M.D., 4200 E. Ninth Ave.; *Treasurer,* H. P. Brandenburg, M.D., 155 Metropolitan Bldg. Meets third Tuesday of each month at homes of members.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Chairman, Samuel M. Atkins, M.D., 63 Central Ave., Waterbury; *Secretary-Treasurer,* Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society.

FLORIDA

Florida Radiological Society.—President, H. B. McEuen, M.D., Jacksonville; *Vice-president,* Joseph H. Lucinian, M.D., Miami; *Secretary-Treasurer,* John N. Moore, M.D., 210 Professional Bldg., Ocala. Meetings held in November and at the annual meeting of the Medical Association of Florida in the spring.

GEORGIA

Georgia Radiological Society.—President, James J. Clark, M.D., Doctors Bldg., Atlanta; *Vice-president,* L. P. Holmes, M.D., University Hospital, Augusta; *Secretary-Treasurer,* Robert C. Pendergrass, M.D., Prather Clinic, Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—President, Roe J. Maier, M.D.; *Vice-president,* Adolph Hartung, M.D.; *Secretary,* Chester J. Challenger, M.D., 3117 Logan Blvd. Meetings the second Thursday of each month from October to May, except December, at the Hotel Sherman.

Illinois Radiological Society.—President, Cesare Gianturco, M.D., 602 W. University Ave., Urbana; *Vice-president,* Fred H. Decker, M.D., 802 Peoria Life Bldg., Peoria; *Secretary-Treasurer,* Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—The next meeting will be in Peoria, in May, 1940. The officers are: *Chairman,* Warren W Furey, M.D., 6844 Oglesby Ave., Chicago; *Secretary,* Harry W. Ackemann, M.D., 321 W. State St., Rockford.

INDIANA

The Indiana Roentgen Society.—President, Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect,* H. H. Inlow, M.D., Shelbyville; *Vice-president,* Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer,* Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

MAINE

See New England Roentgen Ray Society.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Chairman, Whitmer B. Firor, M.D., 1100 N. Charles St.; *Secretary,* Walter L. Kilby, M.D., 101 W. Read St. Meetings third Tuesday of each month.

MASSACHUSETTS

See New England Roentgen Ray Society.

MICHIGAN

Detroit X-ray and Radium Society.—President, Sam W. Donaldson, M.D., 326 N. Ingalls St., Ann Arbor; *Vice-president,* Clarence Hufford, M.D., 421 Michigan Ave., Toledo, Ohio; *Secretary-Treasurer,* E. R.

Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave.

Michigan Association of Roentgenologists.—President, C. K. Hasley, M.D., 1429 David Whitney Bldg., Detroit; *Vice-president,* M. R. Cooley, M.D., Mercy Hospital, Jackson; *Secretary-Treasurer,* C. S. Davenport, M.D., 609 Carey St., Lansing. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—President, Leo G. Rigler, M.D., University Hospital, Minneapolis; *Vice-president,* Harry M. Weber, M.D., Mayo Clinic, Rochester; *Secretary,* John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. These officers will assume their duties after the Summer meeting which will be held in connection with the Minnesota State Medical Society, May 31 to June 2, 1939.

MISSOURI

The Kansas City Radiological Society.—President, L. G. Allen, M.D., 907 N. 7th St., Kansas City, Kansas; *Secretary,* Ira H. Lockwood, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—President, Paul C. S[illegible]noebelen, M.D.; *Secretary,* W. K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—President, T. T. Harris, M.D., Clarkson Memorial Hospital, Omaha; *Secretary,* D. Arnold Dowell, M.D., 117 S. 17th St., Omaha. Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island.) *President,* Langdon T. Thaxter, M.D., Maine General Hospital, Portland, Maine; *Secretary,* Aubrey O. Hampton, M.D., Massachusetts General Hospital, Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

Radiological Society of New Jersey.—President, P. S. Avery, M.D., Middlesex Hospital, New Brunswick; *Vice-president,* J. G. Boyes, M.D., 912 Prospect Ave., Plainfield; *Treasurer,* H. A. Vogel, M.D., 1060 E. Jersey St., Elizabeth; *Secretary,* W. James Marquis, M.D., 198 Clinton Ave., Newark; *Counsellor,* A. W. Pigott, M.D., Skillman. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—President, Henry A. Barrett, M.D., 140 East 54th St., New York City; *President-elect,* I. J. Landsman, M.D., 910 Grand Concourse, New York City; *Vice-president,* Frederic E. Elliott, M.D., 122 76th St., Brooklyn; *Treasurer,* Solomon Fineman, M.D., 133 East 58th St., New York City; *Secretary,* William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—President, Albert Voltz, M.D., 115–120 Myrtle Avenue, Richmond Hill; *Vice-president,* A. L. L. Bell, M.D., Long Island College Hospital, Henry, Pacific, and Amity Sts., Brooklyn; *Secretary-Treasurer,* E. Mendelson, M.D., 132 Parkside Ave., Brooklyn. Meetings first Tuesday in each month at place designated by president.

Buffalo Radiological Society.—President, Chester D. Moses, M.D., 333 Linwood Ave.; *Vice-president,* Edward C. Koenig, M.D., 100 High St.; *Secretary-Treasurer,* Joseph S. Gian-Franceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen-ray Society.—President, W. E. Achilles, M.D., 60 Seneca St., Geneva; *Vice-president,* M. T. Powers, M.D., 250 Genesee St., Utica; *Secretary-Treasurer,* Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings held in January, May, and October as called by Executive Committee.

Long Island Radiological Society.—President, Samuel G. Schenck, M.D., Brooklyn; *Vice-president,* G. Henry Koiransky, M.D., Long Island City; *Secretary,* Marcus Wiener, M.D., 1430 48th St., Brooklyn; *Treasurer,* Louis Goldfarb, M.D., 608 Ocean Ave., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—President, Harry M. Imboden, M.D., 30 W. 59th St., New York City; *Vice-president,* Henry K. Taylor, M.D., 667 Madison Ave., New York City; *Secretary,* Roy D. Duckworth, M.D., 170 Maple Ave., White Plains, N. Y.; *Treasurer,* Eric J. Ryan, M.D., St. Luke's Hospital, New York City.

Rochester Roentgen-ray Society.—Chairman, Joseph H. Green, M.D., 277 Alexander St.; *Secretary,* S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—President, Robert P. Noble, M.D., 127 W. Hargett St., Raleigh; *Vice-president,* A. L. Daughtridge, M.D., 144 Coast

Line St., Rocky Mount; *Secretary-Treasurer*, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

Cleveland Radiological Society.—*President*, J. H. West, M.D., 10515 Carnegie Ave.; *Vice-president*, Harry Hauser, M.D., City Hospital; *Secretary-Treasurer*, H. A. Mahrer, M.D., 10515 Carnegie Ave. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*President*, B. M. Warne, M.D., Doctors Building, Cincinnati; *Secretary-Treasurer*, Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—*President*, Charles S. Caldwell, M.D., 520 S. Aiken Ave., Pittsburgh; *First Vice-president*, Thomas L. Smyth, M.D., 111 N. 8th St., Allentown; *Second Vice-president*, Reuben G. Alley, M.D., Western Pennsylvania Hospital, Pittsburgh; *Secretary-Treasurer*, Lloyd E. Wurster, M.D., 416 Pine St., Williamsport; *President-elect*, Louis A. Milkman, M.D., 212 Medical Arts Bldg., Scranton; *Editor*, William E. Reiley, M.D., Clearfield.

The Philadelphia Roentgen Ray Society.—*President*, H. Tuttle Stull, M.D., 3260 N. Broad St., Philadelphia, Penna.; *Vice-president*, Joseph E. Roberts, Jr., M.D., 403 Cooper St., Camden, N. J.; *Secretary*, Barton R. Young, M.D., Temple University Hospital, Philadelphia, Penna.; *Treasurer*, Fay K. Alexander, M.D., Chestnut Hill Hospital, Philadelphia, Penna.

The Pittsburgh Roentgen Society.—*President*, Zoe A. Johnston, M.D., 601 Jenkins Arcade; *Vice-president*, Prentiss A. Brown, M.D., and *Secretary-Treasurer*, Harold W. Jacox, M.D., 4800 Friendship Ave. Meetings held second Wednesday of each month at 4:30 P.M., from October to June at various hospitals designated by program committee.

RHODE ISLAND

See New England Roentgen Ray Society.

SOUTH CAROLINA

South Carolina X-ray Society.—*President*, Percy D. Hay, Jr., M.D., McLeod Infirmary, Florence; *Secretary-Treasurer*, Hillyer Rudisill, Jr., M.D., Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—*President*, Steve W. Coley, M.D., Methodist Hospital, Memphis; *Vice-president*, Eugene Abercrombie, M.D., 305 Medical Arts Bldg., Knoxville; *Secretary-Treasurer*, Franklin B. Bogart, M.D., 311 Medical Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—*President*, Jerome H. Smith, M.D., San Antonio; *President-elect*, C. F. Crain, M.D., Corpus Christi; *First Vice-president*, M. H. Glover, M.D., Wichita Falls; *Second Vice-president*, G. D. Carlson, M.D., Dallas; *Secretary-Treasurer*, Henry C. Harrell, M.D., 517 Pine St., Texarkana. Meets annually. Temple is place of next meeting.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

Radiological Society of Virginia.—*President*, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president*, L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary*, V. W. Archer, M.D., University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society.—*President*, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Secretary*, T. T. Dawson, M.D., Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

WISCONSIN

Milwaukee Roentgen Ray Society.—*President*, H. W. Hefke, M.D.; *Vice-president*, Frederick C. Christensen, M.D.; *Secretary-Treasurer*, Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—*Secretary*, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—*Secretary*, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

I. SETH HIRSCH, M.D.: AN APPRECIATION

"Little call as he may have to instruct others, he wishes nevertheless to open out his heart to such as he either knows or hopes to be of like mind with himself, but who are widely scattered in the world. He wishes to knit anew his connections with his oldest friends, to continue those recently formed, and to win other friends among the rising generation for the remaining course of his life. He wishes to spare the young those circuitous paths, on which he himself had lost his way."

Thus wrote Goethe in his "Introduction to the Propyläen," symbolic of the gateway of the Acropolis of Athens and which offers us an appropriate introduction to the Periclesian work of Dr. I. Seth Hirsch in the temple he has erected to roentgenology. For Goethe's thought touches vitally upon many of the aspects of the life and work of the one this group of papers would memorialize, above all his capacity for knitting his early memories and his many friendships into an integral part of his personality.

Constantly striving forward, with a dynamic curiosity concerning people and things, in spite of difficulties in looking backward, his course through life has shown that consistent bringing of the past to blend with the present and to supply the impulse to mastery of the future.

Living his life in New York City, he has always been surrounded by its tumultous environment. His response to Nature and to people has been vivid, wide, and deep even in his boyhood, and these early stirrings to enter into the heart of things have remained with him throughout the years. The city and its people have a fascination for him which has carried him deeper and deeper into the study of the form and function of the forces molding human destiny as revealed in the internal structure of the human body.

As he himself has told me, one of his earliest memories is of a small churchyard near his home in the city, where two trees so grew as to provide an arching frame and where he would come and gaze for hours, enthralled by the beauty of Nature and also by a curiosity about a slim madonna, in flowing robes, in a niche above the doorway, facing the sky, her hands clasped in prayer. There was a certain furtiveness in this rapture, as it had no counterpart in the strict orthodoxy of his home.

It was but natural that order and form should become second nature to him and that the reading of military campaigns, strategic matching of forces, should have been a passion with him as a boy. He was rarely satisfied with things as they were told to him but was ever experimenting with new methods and contrivances that lay outside of his regular curriculum.

At the College of Physicians and Surgeons, from which he was graduated in 1902, his heroes were Delafield and Hartley, the reporting of the latter's surgical clinics obtaining for him the Harsen Prize. There were also the close contacts with such departing giants as Starr, Bull, Jacobi, and Weir, all noted for their systematic and orderly pedagogic aptitudes as well as their capacity for making new advances in medicine.

Curiosity drove him to the microscope and the bacteriological laboratory and this searching went further into the new discipline of seeing into things just being opened up by the discoveries of Roentgen. Economic needs made of him a general practitioner, fortunately made profitable by a generous patron. He thus went through the arduous, informing, and busy work of general practice with all of its vexations, and fascinations, as he has written it, "Waiting until the cold gray dawn for the head to appear on the perineum, improvising the kitchen furniture and utensils to serve as operating room accessories, witnessing the joys and tragedies of birth and death, and playing the part of the god in the machine in straightening out physical and spiritual entanglements."

As bacteriology offered no means of a livelihood he turned to radiology, entering the field almost as a newcomer who had to construct his own equipment, which temperamentally was "up his alley," as he had already improvised several obstetrical gadgets and it was a natural advance to tubes, tables, holders, and new methods of getting on the inside of things.

Then in 1910, after a Civil Service examination, he was appointed "X-ray Photographer" to Bellevue Hospital. Here again his love for order gave him plenty of scope in rearranging the entire outfit, and for sixteen years endless opportunities for study and for service made his life an arduous, happy, and busy one.

As he says in one of his letters, "My sixteen years there were busy years. Endless opportunities for study, the association with outstanding figures in the medical world, and the contact with students made the years interesting though arduous.

"They were happy years of experimentation and development and association with such men as Norrie, Draper, Stewart, and Norris. These men definitely influenced my attitude and method of approach to scientific problems and the scientific life. They were difficult and troublesome years of continual contention with lay stupidity and ignorance, which assumes the responsibility of directing municipal affairs, bureaucrats, mentally incapable of understanding the continual change in front demanded by advancing medical knowledge and tacitly agreeing to the dictation of the ward heelers and district leaders in hospital matters.

"In spite of continued opposition, I persisted in impudent demands for more space, more equipment, and larger personnel and four years after I entered the hospital, the department was relocated in the place where it still is. It is pleasant to recollect how beautiful was this laboratory, then one of the largest in this country. There was a harmony between appearance and utility in the numerous rooms. Many came to admire its color and orderliness, others the arrangement of its equipment which was then the best which could be purchased or designed, others the technical methods and application to the rapidly expanding field of diagnosis.

"All this was many years ago but time and other corroding factors have since then accomplished their devastating effects."

Now he could turn to writing, and in 1920 his "Principles and Practice of Roentgen Technic," appeared, to be followed in 1925 by his "Principles and Practice of Roentgen Therapy," a pioneer work in English deemed worthy of translation by Holzknecht and Spiegler.

From the beginning he saw beauty, or, to paraphrase Pope, "order as Heaven's first law" and built upon this order his intellectual foundations, giving himself a springboard to his advancements. For his love for getting into the inside of things has enabled him to be an innovator, a discoverer, and a leader, all of which attributes have been appreciated by his confrères. This orderliness has given him the capacity to integrate the teachings of radiology with the basic subjects of anatomy, physiology, and pathology, not to make radiologists of all medical students but physicians for whom the physico-chemical agencies stemming from the discoveries of Roentgen become tools for clinical medical research and therapeutics.

Since 1933 Dr. Hirsch has been Professor of Radiology in the New York University Medical School. Throughout the years there have come from his industry studies characterized by originality, freshness of view point, and a striving for simplification. Particularly noteworthy, however, are his most recent ingenious contributions to the analysis of cardio-dynamic phenomena by permanent roentgen records. Also, he has opened up a new field of kymophono-roentgenography, thus making possible the studying and recording of sound phenomena of the heart and the valvular action responsible for it. He has "hitched" the heart to the x-ray machine in such a manner as to picture this organ in definite phases of its activity.

To his clinical research work he has brought a highly cultivated appreciation of the beauties of Nature. He is a sculptor of note, derived from his sense of beauty of line and its organization, and is no mean artificer in words. In his summer home he has partially realized his dream of a Castle in Spain. It is a place of great beauty and charm, overlooking a valley supreme in its feeling of rest and contentment, symbolic of his inner rapport with Nature, where the "miracle of the Spring to come sharpens his desire for more years of life."

He is still young in years and even younger in striving to bring what was in darkness and confusion to light and order. From Aurelius he early took the precept not to be in love with men's praises. "Behold," he says, "what judges they are in matters which concern even themselves."

I hold it no small privilege to be able to add these few words of appreciation in this plan of friends, associates, colleagues, co-workers, and pupils to mark the outstanding achievements in the field of roentgenology of my friend, I. Seth Hirsch. Long may he live in the body to carry on his work so ably begun!

SMITH ELY JELLIFFE, M.D., Ph.D.

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ANNOUNCEMENTS

REFRESHER POST-GRADUATE SERIES

The Second Annual Refresher Post-graduate Series of the Radiological Society of North America will be offered at the next Annual Meeting, in Atlanta, December 11–15, 1939.

The Executive Committee has set aside Sunday, December 10, afternoon and evening, and from 8 A.M. to 10 A.M. each day of the week during the meeting. The clinics previously held have been abandoned for this year.

Most of the courses offered last year will be repeated and, in addition, a series of basic subjects will be presented by other teachers of national reputation. The courses vary in the total time they occupy. Some of the longer courses will be presented sequentially at the same hour on consecutive days.

The Executive Committee has also ruled that no charge will be made and that members of the Society will be preferentially enrolled. It is the hope of the Committee on Publicity and Education to make the Second Annual Refresher Series basic in its consideration and comprehensive in its scope.

The Committee on Publicity and Education will be pleased to receive comments and helpful suggestions.

MID-SUMMER RADIOLOGICAL CONFERENCE IN THE ROCKY MOUNTAINS

DENVER, COLORADO, JULY 27, 28, 29, 1939

Headquarters, Hotel Shirley-Savoy

Preliminary Announcement: Guest Speakers

Hans A. Jarre, M.D., Detroit, Michigan
James F. Kelly, M.D., Omaha, Nebraska
Sherwood Moore, M.D., St. Louis, Missouri
Bernard H. Nichols, M.D., Cleveland, Ohio
Wendell G. Scott, M.D., St. Louis, Missouri
Paul F. Titterington, M.D., St. Louis, Missouri
Edith H. Quimby, M.S., New York City
Helen Quincy Woodard, M.D., New York City
Symposium on "The Radiation Therapy of Inflammations."
Symposium on "The Radiation Therapy of the Diseases of the Blood and the Blood-forming Organs."
Symposium on Urology
Miscellaneous Subjects—Round Table Discussions.

AMERICAN COLLEGE OF RADIOLOGY

The new officers of the American College of Radiology are as follows: *President,* Fred M. Hodges, M.D., Richmond, Virginia; *Vice-president,* J. C. Dickinson, M.D., Tampa, Florida; *Treasurer,* E. L. Jenkinson, M.D., Chicago, Illinois; *Secretary,* Mac F. Cahal, Chicago, Illinois.

The next annual conference of the College will be held in Chicago at the Palmer House in February, 1940. The next annual meeting of the College will be held in New York City on June 12, 1940.

AMERICAN CONGRESS OF PHYSICAL THERAPY

The eighteenth annual scientific and clinical session of the American Congress of Physical Therapy will be held Sept. 5, 6, 7, 8, 1939, at the Hotel Pennsylvania, New York City. Preceding these sessions the Congress will conduct an intensive instruction seminar in physical therapy for physicians and technicians, August 30, 31, September 1 and 2.

The instruction seminar should prove of unusual interest to physicians and technicians. The clinics which comprise half of the schedule make this course outstanding for its practical

value. As in the past, outstanding clinicians and teachers will participate. Registration is limited to 100 and is by application only. For information concerning seminar and preliminary program of convention proper, address American Congress of Physical Therapy, 30 North Michigan Avenue, Chicago.

COMMUNICATIONS

THE SOLOMON MEMORIAL LIBRARY OF RADIOLOGY

To honor and perpetuate the memory of Dr. Iser Solomon, the eminent French radiologist who recently passed away, Madame Solomon has donated her late husband's radiological library to the Faculty of Medicine of Paris. It will be known as the Solomon Memorial Library of Radiology. In order to make this library complete, she asks that the American radiologists whom Dr. Solomon held in great respect and esteem, contribute their publications which have appeared in the last few years and which because of his illness he was not able to acquire. It is suggested that these contributions bear the author's dedicatory inscription.

The contributions are to be addressed to Madame Iser Solomon, 27, Avenue Trudaine, Paris.

It is hoped that the response to her request will be such that the contributions by American radiologists will occupy a prominent place in this Memorial Library.

AN OPPORTUNITY FOR EXCHANGE

The Editor has received a most interesting letter which opens up such an opportunity for some American radiologist that he is publishing it herewith.

A radiologist located in the Near East is to go on furlough in 1940 for about eight to twelve months. He would like to exchange positions for that length of time with an experienced hospital or university radiologist in the United States. He continues:

"We could exchange houses, cars, and work while keeping our own salaries. My department is not well housed at present, but equipped and staffed satisfactorily. The material of observation is exceedingly interesting, and conditions of work, although quite pleasant, differ entirely from those in large American institutions. Teaching consists of lectures and post-graduate courses. This is a very nice city to live in, in a beautiful country, and the Near East is a fascinating part of the world. There is a fine American and European community; and the people of the country are most pleasant to live with.

"As to myself, you know some of my work; I think it would not be difficult for me to fit in somewhere else. I am 39 years old; after having been in charge of two large teaching departments in Germany, I came here as professor of radiology about five years ago. I do not know much about radium, but am otherwise familiar with both the diagnostic and therapeutic sides of radiology. I have held teaching positions since 1930."

The Editor will forward promptly to the writer of the above letter any inquiries which may be sent to him.

INTERNATIONAL COLLEGE OF SURGEONS

The Fourth Annual Assembly of the International College of Surgeons was held at the Hotel Roosevelt, New York City, May 21–25, 1939. More than 500 representatives of 30 nations participated. Internationally famous surgeons lectured to the assembly on their own latest developments in surgical technics.

The International College of Surgeons is composed of subsidiary national chapters, each being subject to the rules and code of ethics of the medical associations of its particular country. The College itself consists of Fellows and Members, their rank dependent on surgical standing, experience, and age. One of its important functions is to help the younger man; hence associate memberships have been established.

The officers for 1939 are: *International President*, Dr. André Crotti, of Columbus, Ohio; *International President-elect*, Dr. Fred H. Albee, of New York City; *United States Chapter President*, Dr. Frederick M. Douglass, of Toledo, Ohio; *Executive Secretary*, Dr. Edward Frankel, Jr., of New York City; *Editor of the Journal*, Dr. Max Thorek, of Chicago, Illinois.

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY

The annual meeting of the Section on Radiology, Connecticut State Medical Society, was

held May 25, 1939, at Hotel Taft, New Haven, Conn. Dr. Samuel A. Robins, of Boston, Mass., presented a paper on "Recent Radiologic Advance in Urologic and Gynecologic Diagnosis," illustrated with slides. After the scientific meeting the following officers were elected for the ensuing year: *Chairman*, Samuel M. Atkins, M.D., Waterbury, Conn.; *Secretary-Treasurer*, Max Climan, M.D., Hartford, Conn.

FLORIDA RADIOLOGICAL SOCIETY

The Spring Meeting of the Florida Radiological Society was held at the Princess Issena Hotel, Daytona Beach, Florida, on May 1 and 2, 1939. One session was devoted to the study of case histories, illustrated by films; another session to therapeutic problems affecting radiology.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY

The Illinois State Medical Society, Section on Radiology, met in Rockford, in May, and the meeting was most successful. At the annual dinner an election was held, with the following results: *Chairman*, Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago, Illinois; *Secretary*, Harry W. Ackemann, M.D., 321 W. State St., Rockford, Illinois.

The next meeting will be held in Peoria, Illinois, in May, 1940, the exact date to be announced later.

INDIANA ROENTGEN SOCIETY

The annual meeting of the Indiana Roentgen Society was held in Indianapolis on May 21. John D. Camp, M.D., of Rochester, Minn., was a guest for the day and after a dinner in the evening read a paper entitled "Roentgenology of the Calvarium." The following new officers were installed: *President*, Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect*, H. H. Inlow, M.D., Shelbyville; *Vice-president*, Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer*, Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis.

KENTUCKY RADIOLOGICAL SOCIETY

A meeting of the radiologists of Kentucky was held at the Brown Hotel in Louisville, April 29, 1939, and the Kentucky Radiological Society was organized. D. B. Harding, M.D., of Lexington, was elected *President;* I. T. Fugate, M.D., of Louisville, *Vice-president*, and Joseph C. Bell, M.D., of Louisville, *Secretary-Treasurer*. Meetings are to be held annually in Louisville, on the third Sunday afternoon in April.

A dinner was served after the business meeting and, following this, Raymond Beeler, M.D., and James N. Collins, M.D., of Indianapolis, spoke to the society concerning the work of the Indiana Roentgen Society.

YOUNG MEN OFFERED FREE SUMMER COURSE ON TRAINING SHIP

The American Nautical Academy, National Training School for Merchant Marine Officers, Washington, D. C., announces that boys and young men between the ages of 11 and 21 years will be allowed to secure practical ship experience on board a training ship of the Academy within the period from June 1 to October 1, 1939.

The young men may remain on board ship for the entire period, or for any shorter time they may wish, but not for less than a month. Students who enter for any period less than the full course will receive instruction only in those subjects being taught while the student is on board ship.

The purpose of the course is: First, as a foundation for those who wish to become officers in the Merchant Marine, and devote their lives to a career in the service; secondly, for those boys and young men who, though not desirous of following the sea, still wish to obtain a general knowledge of ships, and the life afloat.

There is no charge for instruction nor for living quarters on board ship. The only required expense is for meals, which are 49 cents. Three meals are served daily.

There is no tuition charge for any of the courses offered by the Academy, and no obligation for future merchant marine, military or naval service of any kind is incurred by the young men.

The schoolship to which the young men will be assigned is the Training Ship *Marsala*,

a vessel of 2,422 tons, 284 feet long, 45 feet breadth, and built in 1919–20.

On Sundays the cadets will be allowed to attend divine services at the churches of their respective denominations on shore. While on board ship cadets will receive free minor first aid treatment when necessary.

This is the tenth annual summer course offered by the Academy, and will be under the personal supervision of the Captain Commandant of the Academy who will be in command of the vessel.

While on board ship the students will follow the regular daily ship routine, and will be given practical instruction in nautical subjects, including seamanship (ship's work), signaling, rowing, handling and the use of motor boats, pulling boats, life-saving, and naval drills. Many of the duties on board ship are performed by the cadets as part of their training. They will also receive instruction in the use of life buoys, first aid, the compass, log, lead, ground tackle, and the duties of lookouts, as well as the duties of the watch on deck.

Students will join the training ship at Virginia where the vessel will be based at Hampton Roads for the summer training period.

Those completing the summer course with a passing grade will be eligible to apply for a scholarship in the Navigation Course.

Due to the fact that the number of accommodations available is limited, those wishing to take advantage of this opportunity should write at once to the American Nautical Academy, National Training School for Merchant Marine Officers, Washington, D. C.

AUTHOR'S NOTE OF CORRECTION

Dr. William H. Meyer has written the Editor that, in abstracting his article, "The Co-relation of Physical and Clinical Data in Radiation Therapy," published in RADIOLOGY in January, 1939, **32**, 23–45, he has discovered an error which he considers of sufficient importance to request a correction.

On page 37, in the legend for Quantitative Chart No. 11, there is an error in the figures: "(60 r/min.)" should read "(90 r/min.)." The last sentence of two and one-half lines should read as follows:

"Thus, if one changes from (90 r/min.) at 200 kv. and 0.75 mm. Cu filter at 50 cm. S.F.D. to (15 r/min.) at 200 kv. and 2 mm. Cu filter at 70 cm. S.F.D., the total r dose required for a given reaction will increase from 500 r at 90 r/min. to 750 r at 15 r/min."

IN MEMORIAM

BYRON HUBBARD JACKSON, M.D.

Once again Death has stretched forth her hand to claim a valued, beloved, and highly honored member of the Radiological Society of North America in the person of Byron Hubbard Jackson, M.D., of Scranton, Pennsylvania. His illness, of short duration, was known to few, hence his passing on May 16, 1939, came as a great shock to all his friends.

Born in Dallas, Pennsylvania, on Sept. 22, 1873, a son of Mr. and Mrs. John C. Jackson, he spent his boyhood and received his elementary education there. He matriculated at the University of Maryland, from which he was graduated in medicine, in 1898. At the turn of the century, Dr. Jackson began practice with the late Dr. John Price, in Scranton. X-ray development was in its infancy at that time, but as the years went on, Byron H. Jackson was to know fame and gain recognition through the practice of the expanding science of radiology.

In 1933, he served as President of the Radiological Society of North America, during which time he revealed his capacity for able leadership. His acts and influence, official and personal, aided in the development of new and useful devices, in the extension of education in radiology in medical schools, and in the general welfare of the Society. He gained for himself the admiration and devotion of his fellow-members. He was witty, affable, generous, and always manifested a keen interest in the young physician specializing in radiology. He had a large part in the founding of the American Board of Radiology, which was destined to play so important a rôle in raising the standards of education in radiology.

Nor were his honors and activities confined to his specific field nor to our Society. Shortly after becoming established in Scranton, his talents won recognition from his associates and he was elected President of the Lackawanna County Medical Society and later served as its Librarian for several terms. In 1932, English physicians conferred a high honor upon

him by electing him a corresponding honorary member of the Royal Society of London, England. Dr. Jackson was one of six specialists elected to this office and the only one from the United States.

The late BYRON H. JACKSON, M.D.

His work in roentgenology having won Dr. Jackson recognition not only locally, but in the national and even in the international field, many tempting offers came within his grasp to establish himself in a larger field where the opportunities from a purely monetary standpoint would be greater. Dr. Jackson, however, was unwilling to give up the practice and the associations which he had formed in the local community where he made his home. Therefore, he stayed on in Scranton, giving generously of his time to the hospitals of that small city. The physicians who were his associates and those whom he had come to know through his wider contacts in state, national, and international medical societies will alike mourn his passing.

Nor were Dr. Jackson's attainments confined to the study of medicine and his chosen specialty of radiology: he was considered an authority on the Bible, which he studied unceasingly during such leisure as he could command.

In 1928, Dr. Jackson and his wife (*née* Eldridge) made an extensive tour of Europe, among other places, visiting the Radiumhemmet, Stockholm's famed institution for the treatment of cancer by radiation, and the Radium Institute of Paris, where Mme. Curie performed her famous experiments.

Dr. Jackson's professional experiences and connections might well be the envy of any ambitious radiologist. For twenty years he was the chief radiologist at the State Hospital, and served in a similar capacity for many years at the Hahnemann Hospital. At the time of his death he was chief radiologist at the Moses Taylor, West Side, and St. Mary's hospitals. He was a member of his county, state, and national medical societies, also the American College of Physicians, the American Roentgen Ray Society, the American College of Radiology, the Radiological Society of North America, and he was a diplomate of the American Board of Radiology. In all of these, he had held office at one time or another.

To his widow, three daughters, and two sons who survive him, we express our sincere sympathy; they have lost a devoted and beloved husband and father. Our Society has lost an ardent and highly esteemed member, and radiology has lost an able exponent.

ELWOOD E. DOWNS, M.D.

Stricken with an embolism while recuperating from an appendectomy, Elwood E. Downs, M.D., 49 years of age, secretary and treasurer of the Underwood Hospital, of Woodbury, N. J., and widely known radiologist, died suddenly on March 18, 1939. Dr. Downs' recovery following the operation had so far advanced that he had planned to return to his home the next day. He was stricken while sitting in a chair.

Dr. Downs also served as radiologist at Jeanes Hospital, Fox Chase, Pa., and the Salem County Memorial Hospital. He was a recognized authority in this branch of medical practice, and was a Fellow of the American College of Radiology, a past president of the Philadelphia Roentgen-ray Society, a member of the American Roentgen Ray Society, the Radiological Society of North America, and a diplomate of the American Board of Radiology. He was twice president of the Gloucester

County Medical Society and a member of the American Medical Association.

A native of Franklinville, Dr. Downs was graduated from Hahnemann Medical College, after which time he practised for several years at Mullica Hill and Swedesboro, before becoming affiliated with Underwood Hospital. He was elected secretary and treasurer of the hospital in July, 1929. J. Harris Underwood, M.D., head of the hospital, who has been recuperating in Florida following a serious illness, was notified of Dr. Downs' death, and immediately left by train for Woodbury.

Surviving are his wife, Lydia Pratt Downs, and three children: Miss Jane Downs, a student nurse at the Pennsylvania Hospital; Hunter, a pre-medical student at Colgate University, and Richard, ten years old.

Civic honors were accorded Dr. Downs by the city of Woodbury, N. J., where his funeral, the largest for many years, was held. The schools were closed and, by the mayor's proclamation, flags on the city buildings were lowered to half-mast for a period of thirty days.

EDSON S. CUMMINGS, M.D.

(1875–1939)

Dr. Edson S. Cummings, widely known roentgenologist and practising physician of Portland, Maine, for more than twenty years, died there of pneumonia on April 11, 1939. Born in Lewiston, Dec. 7, 1875, Dr. Cummings received his early education in his native city. Following special study at Bowdoin College, he studied at Bowdoin Medical School, being graduated in 1900. First engaged in practice in Lewiston, he was also an attending physician at the Central Maine General Hospital until he entered the medical service when the United States entered the World War. He had since been connected in an advisory capacity with the Lewiston institution. During the World War Dr. Cummings was stationed at Camp Funston, Fort Riley, Kansas, being in charge of the x-ray work at the hospital there, following special work at the Military School of Roentgenology at Kansas City, Mo. He was on duty at Fort Riley until Jan. 8, 1919, when he was honorably discharged, holding the rank of captain at that time.

Returning to Maine, Dr. Cummings soon after located in Portland, where he had been in active practice since. He was for twenty years on the staff of the Maine Eye and Ear Infirmary, in addition to his private practice.

Dr. Cummings was one of the founders of the Medical Research Club, of Lewiston, and took an active part in the County and State Associations. He was a member of the Maine Medical Association, the American Medical Association, and the Radiological Society of North America.

Dr. Cummings' passing is an occasion of grief to his friends in the Society, who extend sincere sympathy to his family.

CHARLES HORACE MAYO, M.D.

The following editorial comment concerning the career of Charles H. Mayo, M.D., is reprinted from the *British Medical Journal* of June 3, 1939. It is such an understanding tribute that it is reprinted here, by courtesy of that Journal.

"The death of Charles Mayo removes one of the greatest figures in surgery, and breaks the most famous partnership of brothers in history. The story of the early days of this wonderful family is common property. How William Worrall Mayo, a young Manchester chemist, emigrated to the United States in 1845, and travelled slowly west in search of opportunity, learning medicine as he went, first as an apprentice in Indiana and later at the infant University of Missouri, then an outpost in hostile country: how he moved with his young family to Minnesota, where he was provost surgeon during the Civil War, and was sent in 1862 with an expedition to quell the Sioux rising, bringing back the skeleton of a chief to teach his sons osteology: how he watched their education in the midst of an ever-growing practice at Rochester: how, helped by his newly graduated elder son, he cared for the victims of a cyclone that swept the town in 1883, and was then asked by the Sisters of the Order of St. Francis to direct the new hospital of St. Mary erected by them in memory of this work: how in 1889 the doctor, now aged 70, took charge of the forty beds, presided over his sons, taught them what he knew of surgery, and handed over the task to them: how the skill of the lads grew and their fame as surgeons spread, so that the work swelled from 751 operations in 1895 to 8,251 in 1910 and 23,628 in 1925: how in 1894 the brothers decided to devote all their earnings, beyond a

yearly sum sufficient to give them reasonable remuneration for their work, to furthering the cause of medical education and the welfare of the sick, and how from this resolve has grown that community of educational foundations, hospitals, parks, and public buildings, that center to which the sick flock for relief and the medical profession for enlightenment, known as the Mayo Clinic.

"In this enterprise, which was unique in its inception and still stands unrivalled in size and scope, the two brothers William and Charles worked for fifty years in complete harmony and unity of purpose, one in their loyalty to the memory of their father and the ideals he set them, one in their devotion to duty and the public welfare. Charles was the younger by four years. He was quiet and simple in his tastes, fond of his home, devoted to his family, delighting in the farm which was attached to his house on the outskirts of Rochester. Like Hunter and Bland Sutton, he had the habits of observation of the naturalist, and sought to apply what he had learned in his work. He was warm-hearted and generous, and became one of the best-loved men in surgery, so that his appearance on a platform was the signal for an ovation that was a tribute to his power of giving and inspiring friendship. He was a forceful and even brilliant speaker when occasion demanded it, but less ready than his brother to enter debate, and his talents were best shown in his genius for clinical discussion and his ready wit, which enabled him to crystallize the results of personal observation in quaint aphorisms that held the fancy and perpetuated his teaching.

"As an operator he was a really brilliant technician, doing work of every kind with a certainty and dexterity that might be equalled by men like Lane or Crile but has probably never been exceeded. When the surgery of the hospital was divided between the brothers, Charles inclined to operations on the head and neck, William to those on the abdomen. Charles led the way in the surgery of the thyroid gland when such work was in its infancy, and earned a reputation for cranial operations, particularly those on the Gasserian ganglion, long before neurosurgery became a separate branch, but whatever he touched he did well. He worked with few instruments, but he could make them do almost anything. His simple outlook can be traced and many of his sayings can be heard in the many theaters where his pupils work to-day.

"But in spite of the characteristics that distinguished them, it is hard to discuss or even to imagine the Mayos apart. It is as the Mayo Brothers that they were known, that they fought their battles and scored their triumphs. At a time when ethics were shaky and commercialism rife, their unquestioned integrity contributed no less than their outstanding surgical skill to establish the reputation of their clinic as a place to which the sick could come for advice and the profession for guidance, happy in the knowledge that neither brother would recommend any course of action or publish any statement without careful thought and firm conviction."

Though Dr. Mayo was not himself a radiologist, he worked so closely with members of our specialty that we may count him as one of ourselves. At the Mayo Clinic, he and his eminent brother established and developed a splendid department of radiology, as all the world knows.

BOOKS RECEIVED

Books received are acknowledged under this heading, and such notice may be regarded as an acknowledgement of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

GASTRO-INTESTINAL DYSFUNCTION. By BARTON ARTHUR RHINEHART, A.B. (Zoology), M.D., Cum Laude (Indiana) A.O.A., Associate Prof. of Roentgenology, University of Arkansas School of Medicine; Consulting Roentgenologist to St. Vincent's Infirmary, Arkansas Baptist Hospital, and Arkansas Children's Hospital; Roentgenologist, Little Rock General Hospital; Member Radiological Society of North America. A volume of 311 pages, with 48 plates. Published by Central Printing Company, Little Rock, Arkansas, 1939. Price not stated.

END-RESULTS IN THE TREATMENT OF GASTRIC CANCER. An Analytical Study and Statistical Survey of Sixty Years of Surgical Treatment. By EDWARD M. LIVINGSTON, B.Sc., M.D., Associate Visiting Surgeon, Bellevue Hospital, New York; Assistant Clinical Professor of Surgery, New York University College of Medicine; formerly Visiting Surgeon, New York City Cancer Institute, and GEORGE T. PACK, B.Sc., M.D., F.A.C.S., Attending Surgeon, Memorial Hospital, New York City; Assistant Professor of Clinical Surgery, the School of Medicine, Yale University, New Haven, and Cornell University Medical College, New York City. With a Foreword by Bowman C.

Crowell, M.D., Associate Director, American College of Surgeons. A volume of 159 pages with numerous charts. Published by Paul B. Hoeber, Inc., New York City, 1939. Price: $3.00. (The material in this volume is reprinted from "The Treatment of Cancer and Allied Diseases," by 142 International Authors, edited by George T. Pack and Edward M. Livingston.)

CANCER HANDBOOK OF THE TUMOR CLINIC, STANFORD UNIVERSITY SCHOOL OF MEDICINE. Edited by ERIC LILJENCRANTZ, M.D., Chief of Tumor Clinic, Stanford University School of Medicine, Consultant in Neoplastic Disease, United States Naval Hospital, Mare Island, and United States Marine Hospital, San Francisco. A volume of 144 pages. Published by the Stanford University Press, Stanford University, California, 1939. Price: $3.00.

MALADIES OSSEUSES (Diseases of Bone). (Recklinghausen's disease, Paget's disease, osseous lipoidosis, multiple myeloma.) By Dr. I. SNAPPER, Professor of the University of Amsterdam. Introduction by Prof. F. De Witte (Gand) and Dr. G. Coryn (Brussels). A volume of 192 pages, with 22 photographic plates. Published by Masson et Cie, Paris, 1939. Price: 330 francs.

BOOK REVIEWS

SILICOSIS AND ASBESTOSIS. By Various Authors. Edited by A. J. Lanza, M.D., Assistant Medical Director, Metropolitan Life Insurance Company; Chairman, Industrial Hygiene Committee of the New York Tuberculosis and Health Association. A volume of 439 pages. Published by Oxford University Press, New York City, 1938. Price: $4.25.

This is a timely contribution concerning a subject that has assumed great importance to industry and diagnostic roentgenology. The Editor is one who has an international reputation for his work in industrial medicine and silicosis in particular. The co-authors are physicians whose contributions to the study of silicosis are well known. To find the opinions and observations of such a group assembled in one textbook is a real medical treat. The contents are divided into seven chapters Chapters 1 and 2, by R. R. Sayers and A. J. Lanza, deal with the history of silicosis and asbestosis and the etiology, symptoms, and diagnosis of silicosis and asbestosis. Chapter 3, by E. P. Pendergrass, is a comprehensive discussion of all the factors pertaining to the roentgen-ray diagnosis. Chapter 4, by S. R. Gloyne, pertains to the pathology of the condition. In Chapter 5, L. O. Gardner presents his well-known observations relating to the experimental pathology of pneumoconiosis. E. L. Middleton, in Chapter 6, presents important observations covering the occupational, preventive, and legislative aspects of silicosis in Great Britain. In Chapter 7, Lanza discusses the public health and economic aspects as they relate to the United States. A comprehensive bibliography for each chapter and a detailed subject index add greatly to the value of the contents.

THIRD SYMPOSIUM ON SILICOSIS. Official transcript of the Third Silicosis Symposium held in connection with the Trudeau School of Tuberculosis at Saranac Lake, New York, June 21 to 25, 1937. A volume of 266 pages. Edited and published by B. E. Kuechle, Vice-president and Claims Manager, Employers Mutual Liability Insurance Company, Wausau, Wisconsin, 1937. No price given.

In this book are published papers or abstracts of papers concerning all phases of silicosis, by various physicians and scientists well known in silicosis work. It needs little introduction to those who are interested in this problem and it should be of special interest to roentgenologists. The abstracts of the discussion concerning each paper greatly enhance the value of the work. The general arrangement of subjects is much the same as that followed in previous symposia except that a paper on legislative control and compensation by T. C. Waters has been added. No little praise should go to the publishers whose generosity makes these booklets possible.

KLINIK DER LUNGENASBESTOSE. Klinische, statistische, und röntgenologische Ergebnisse aus Reihenuntersuchungen an Asbestarbeitern über Krankheitsbild und Verlauf der Asbestose (Clinical Aspect of Asbestosis of the Lung. Clinical, Statistical, and Roentgenological Results of Serial Examinations on Workers in Asbestos Factories Regarding the Clinical Picture and Course of Asbestosis). By HANS-WILFRID WEDLER. A monograph of 152 pages, with 36 illustrations. Published by Georg Thieme, Leipzig, 1939. Price: 7.80 RM, bound; 6.50 RM, paper.

The author examined 310 individuals working in asbestos factories and presents an

analysis of his findings in this monograph. From a historical standpoint it is interesting to note that Plinius is said to have described asbestosis under the name of "slave disease," while the first accurate recent information must be credited to Murray, who in 1899 published the postmortem findings in a worker who had died at the age of 33 after working 10 years in an asbestos factory. The autopsy showed fibrosis of the lungs with asbestosis but no tuberculosis.

Following a brief review of the German literature on the subject the author relates in detail his own experience, arranged under the following headings: Methods of Examination and Discussion of the Clinical Material, Pathogenesis of Asbestosis, Evaluation of Anamnestic and Clinical Studies, the Asbestosis Warts, Roentgen Findings, Blood Picture, Histological Connection between Asbestosis and Tuberculosis and Carcinoma, the Dust Hazard in Factories, the Clinical Course of the Disease, Postmortem Examinations, and Medico-legal Comments. The author's statistics show that 77.4 per cent of the examined workers were either free from the disease or had it in its very early stages, 14.8 per cent belonged to Stage 1, 4.8 per cent to Stage 2, and 2.9 per cent to the advanced Stage 3. Data on all cases studied are compiled in a table giving information on age, sex, type of work, cough, sputum, dyspnea, pain, whether or not bronchitis, pleuritis, or emphysema were present, expansion of thorax, including vital capacity, and blood sedimentation. In 174 cases an electrocardiogram was taken. No positive proof could be obtained that any damage to the right heart was caused by the asbestosis. Six workers died, five were autopsied, and reports on three are given with microscopic findings. A short bibliography includes references to the international literature. The reproductions of the roentgenograms of a series of selected cases are excellent.

ABSTRACTS OF CURRENT LITERATURE

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M. L. Connelly, M.D., of Chicago, Ill.
Benjamin Copleman, M.D., of Perth Amboy, N. J.
Q. B. Coray, M.D., of Salt Lake City, Utah
Lewis G. Jacobs, M.D., of Winona, Minn.
Hans A. Jarre, M.D., of Detroit, Mich.
Eugene T. Leddy, M.D., of Rochester, Minn.
John B. McAneny, M.D., of Madison, Wis.
Max Mass, M.D., of Chicago, Ill.
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CANCER (THERAPY)

Roentgen Therapy of Cancer by the Method of Chaoul. George T. Pack, James S. Gallo, and Boyd F. Wilkinson. Jour. Med. Soc. New Jersey, **36,** 15–21, January, 1939.

The authors have treated over 50 patients with various malignant tumors of the skin, including the lip, and a few intra-cavitary cases, by the Chaoul method. They report highly satisfactory results.

In essence, the Chaoul method is described as a modality for delivering high intensity, low voltage (50–60 kv.) radiation to areas accessible to a contact or up to 5 cm. F.S.D. without injury to the deeper structures. The distribution of radiation in the tissues with this method is similar to that obtained with radium surface applicators and less expensive.

The apparatus used by the authors delivers, on contact application, 800 r per minute, 88 r at 3 cm., and 36 r at 5 cm. The heat generated in the tube is dissipated by a constant flow of cold water, making possible direct contact application. The current supplied by the generator is from 4 to 6 ma.

In the treatment of skin carcinomas, the fractional principle is employed, giving from 300 to 400 r units daily until from 6,000 to 9,000 r units have been administered. With epitheliomas about the eye, daily fractions of from 250 to 400 r units were given with total dosages between 3,000 and 8,000 r units with satisfactory results. Recurrent breast nodules were treated with good results.

In carcinoma of the lip, a cross-firing effect is obtained by both external and internal surface application. Fractionated daily doses of from 300 to 400 r units for total dosages of from 4,000 to 6,000 r units to each portal are used. Chaoul reported 90 per cent absolute cure of 20 patients treated in this way. In the intra-oral application, a target-skin distance of from 3 to 5 cm. is used with a filtration of 0.2 mm. of copper. The total dose ranges from 3,000 to 6,000 r units and is given in daily fractions of from 250 to 300 r units. This method is usually combined with external high voltage therapy, usually 200 kilovolts, 60 cm. target-skin distance, filtration of 1 mm. aluminum and 0.5 mm. copper. The total dosage varies from 3,000 to 5,000 r units given in fractions of 300 r units daily.

Carcinoma of the pharynx can be treated by contact radiation when local anesthesia is used. Post-operative marsupialization of carcinoma of the urinary bladder permits accessibility to this type of radiation. The authors have used 2,500 r units every other day for a total dosage of 25,000 r units.

MAX MASS, M.D.

Cancer of the Penis and its Treatment. C. J. Hansson. Acta Radiol., **19,** 443–457, November, 1938.

During a 25-year period (1912–1937), 106 cases of cancer of the penis were treated at the Radiumhemmet in Stockholm. The material is divided into three groups, according to the extent of metastatic involvement at the beginning of the treatment: Stage 1, Cases without clinically demonstrable gland metastases; Stage 2, Operable cases with clinically demonstrable metastases, and Stage 3, Inoperable cases with metastases beginning to break through the glandular capsule. Sixty-two per cent of the cases belonged to Stage 1, 22 per cent to Stage 2, and 16 per cent to Stage 3. In most cases the treatment was a combination of radiation and surgery; in only a few cases radiotherapy was employed exclusively.

The methods of treatment and the results are analyzed in all cases in which a five-year follow-up was possible. The percentage of five-year cures amounted to 85 per cent in Stage 1 and to 58 per cent in Stage 2. All cases of Stage 3 succumbed within five years. The author is convinced that a combined radiosurgical approach assures the greatest prospect of success in treatment of cancer of the penis.

ERNST A. SCHMIDT, M.D.

Teleroentgentherapy of Carcinomatous Metastases. L. Mallet. Strahlentherapie, **64,** 201, 1939.

The author relates his experience with teleroentgentherapy in the treatment of distant metastases, especially those of the bone. His present technic, in general body exposure, consists of the application of from 25 to 50 r at an F.S.D. of 1.5 meters, 200 kv., 0.5 mm. Cu + 2.0 mm. Al, requiring about one-half an hour for 25 r. This dose is applied at least four times per week, if the general condition of the patient permits as many treatments. The exposure of the thorax, for instance, requires from 30 to 40 single exposures, or a total treatment period of two months, provided that 25 r are given daily. Mallet does not like to exceed from 1,000 to 1,200 r per field per series, but has seen recalcification of bone lesions following doses of from 250 to 300 r per field. Since 1933, he has subjected approximately 600 cases of metastatic carcinoma to teleroentgentherapy. This included bone metastases, advanced primary tumors with glandular involvement, metastases in lungs, pleura, mediastinum, carcinoma of the esophagus, the uterus, the prostate, and some others. Blood examinations at regular intervals are essential, since the white count should not be allowed to drop too low; it is advisable to give transfusions from time to time.

In his series of cases, the author observed some very encouraging remissions. His ideas as to the mode of action of teleroentgentherapy are briefly discussed.

ERNST A. POHLE, M.D., Ph.D.

The Roentgen Treatment of Carcinoma of the Larynx and Hypopharynx. Wendell G. Scott and Sherwood Moore. South. Med. Jour., **32,** 144–150, February, 1939.

Intrinsic carcinomas are those of the interior of the laryngeal box, 98 per cent starting in the vocal cords. These can be diagnosed by inspection and biopsy, and must be differentiated from syphilis and tuberculosis. Laryngofissure is the treatment of choice, if the carcinoma is limited to the cord, with a 76 to 82.3 per cent

five-year survival, but generally radical surgery or irradiation is necessary.

Extrinsic cancer of the larynx comprises from 60 to 70 per cent of all laryngeal cancers and may be primarily extrinsic or due to extension of an intrinsic cancer beyond the larynx. Radical surgery is often of questionable value.

If irradiation is employed, for either intrinsic or extrinsic carcinoma, 14 T.E.D. are delivered to the lesion using three portals, 3,000 r units to each lateral port and 2,000 r anteriorly, with daily doses of from 100 to 300 r measured in air. Two hundred kv., 1 mm. copper, and 50 cm. distance are the factors employed.

This same technic is used for cancers of the hypopharynx in which case 11 T.E.D. are delivered to the lesion. The lateral areas are 50 sq. cm. each and the anterior 27 sq. cm.

JOHN M. MILES, M.D.

Extensive Lymphatic Extension of a Cancer of the Breast: Beneficial Effect of Teleroentgen Therapy. P. Ponthus and A. Boijeau. Bull. et mém. Soc. de radiol. méd. de France, **26,** 374–377, May, 1938.

Three years after removal of the right breast (Halstead's operation) the patient, a woman 41 years of age, presented extensive metastases extending as a diffuse infiltration from the right axillary line past the midline, involving the whole of the left breast, both supraclavicular and axillary regions, and the whole of the right rectus muscle. Films of the chest showed extensive thickening of the pleura on the right with a large effusion.

Teleroentgen therapy, with 200 kv., F.S.D. 1 m. 50 cm., 0.8 cm. Cu, and fields covering the whole body, was administered at the rate of 50 r given every fourth day. A total of 950 r was given. The lesions remained stationary but the general state improved remarkably. Five months later a second series of treatments was given, the factors being: 300 kv., F.S.D. 3 m., 0.5 mm. Cu, 20 r per seance given every four days for a total of 120 r. The blood count was not decreased. The general state, however, declined rapidly and the patient died three weeks later.

S. R. BEATTY, M.D.

CONTRAST MEDIA

An Experimental Study on Hysterosalpingography. Part I.—Accumulation Period and Shadow Picture of the Contrast Medium, Morujodol, Injected into the Rabbit Uterine Cavity. S. Hukada. Jap. Jour. Obst. and Gynec., **21,** 316–318, September, 1938.

The author found that opaque material injected into the rabbit uterus did not flow through the uterine tubes into the abdominal cavity as in the human being. In all but a few cases, after about twenty-four hours, it had all been either discharged from the vagina or had been absorbed so completely that a shadow could not be obtained.

However, when the vagina was tied so as to prevent the outward flow of the opaque material, the majority of cases showed clear shadow films for a period of from 10 to 21 days. One case gave a shadow after 13 months.

W. A. WARD, M.D.

An Experimental Study on Hysterosalpingography. Part II.—On the Accumulation Period and Shadow Picture of the Contrast Medium of Iodic Oil Injected into the Pelvio-abdominal Cavity. S. Hukada. Jap. Jour. Obst. and Gynec., **21,** 319, 320, September, 1938.

Since the opaque material injected into the uterine cavity failed to enter the abdominal cavity, the author injected it directly into the pelvio-abdominal cavity and took roentgenograms at proper intervals from one hour to 200 days after injection.

Several hours after injection a shadow film showed the contrast to be still attached to the organs in the abdomen. Later, however, the opaque material accumulated in groups in several places, but never gave a shadow with a certain definite shape. It was sometimes dotted, sometimes lineal, and sometimes reticular.

The time required for complete absorption varied from 40 to 200 days, depending on the kinds and amounts of the media, rabbit constitution, and other conditions.

The author found the absorption of the media to be faster through the abdominal peritoneum than through the endometrium of the uterine cavities.

W. A. WARD, M.D.

Injection of Lipiodol as a Guide in Estimating the Healing of Acute Empyema Cavities. Henry L. Cabitt and Alfred Hurwitz. New England Jour. Med., **220,** 376–379, March 2, 1939.

This is a presentation of four case histories to illustrate the value and advantage of lipiodol instillation into empyema cavities before the drainage tube is removed. A 40 per cent lipiodol solution is introduced by gravity into the cavity and both lateral and postero-anterior films are made of the chest. This procedure will save many embarrassing occasions for the chest surgeon.

J. B. MCANENY, M.D.

THE ELBOW

An Abnormal Calcification of the Medial Surface of the Elbow. Estève. Jour. de radiol. et d'électrol., **22,** 592, 593, December, 1938.

X-ray examination of the right elbow joint of a man aged 25, who had sustained an injury, revealed a large, smooth, somewhat oval, dense shadow the size of a marble, along the internal aspect of the humerus but not connected to it. Since it did not resemble a fracture fragment, the opposite elbow was x-rayed and a corresponding shadow found. The author recalls a

similar case in which, however, the opposite elbow had not been x-rayed.

In the differential diagnosis, fracture was excluded. A supernumerary bone was considered but it had never been seen nor described. A trochlear nucleus which had never fused seemed unlikely. Cartilaginous "stones" are generally more numerous. The appearance does not suggest osteochondritis dissecans.

A similar case has been reported by Kohler, who recounts two or three other cases of his associates. He does not consider trauma the cause. In one case histologic examination showed the structure to be cartilaginous without any ossification.

The author favors a congenital origin (supernumerary bone) or a developmental anomaly of the trochlear tubercle (absence of fusion). He suggests more frequent examination of the opposite elbow for comparison, even when the injury is in an adult, because of the medico-legal aspect.

J. SAGEL, M.D.

ENCEPHALOGRAPHY

The Diagnostic Evaluation of Subtentorial Accumulation of Air. L. Haas. Fortschr. a. d. Geb. d. Röntgenstrahlen, **58**, 18–33, 1938.

In 102 pneumoencephalographic examinations, air was found 24 times in subtentorial spaces—21 times with cisternal, three times with lumbar injection. This occurrence, as such, is not attributed to any pathognomonic significance. The normal appearance of these subtentorial spaces is described and illustrated. They present themselves better in views obtained when the patient is in a sitting position than when he is lying down. Caution is necessary to avoid confusion with a posterior or inferior horn of the lateral ventricle and with a deep sinus transversus.

At times, subtentorial air adds materially to diagnostic recognition: persistent monolateral filling of this space is pathologic, indicating increased pressure on the non-filled space or reduction of the tissue mass surrounded by the air. Any deviation of the air-band, or encroachment on it, can be of diagnostic significance, especially when the decision between supra- and infra-tentorial tumor has to be made. It has been found, futhermore, that air is present in subtentorial spaces most frequently in cases of posterior occlusion of the normal channels.

H. A. JARRE, M.D.

Cerebral Pneumography in Childhood. A. E. Childe. Canadian Med. Assn. Jour., **39**, 552–555, December, 1938.

Cerebral pneumography includes procedures commonly known as encephalography and ventriculography.

In encephalography spinal fluid is withdrawn by lumbar puncture and replaced with gas. In this manner the ventricular system and also the subarachnoid space are outlined. This method of examination is safe in patients who have no increased intracranial pressure. One of the most common indications for encephalography in childhood is suspected feeble-mindedness or backwardness. Many of the patients present varying degrees of diffuse cerebral atrophy as evidenced by large ventricles which may or may not be symmetrical. In the case of a subdural or extradural hemorrhage, the ventricles shift away from the expanding lesion. When atrophy is present, however, the ventricles enlarge and tend to shift toward the atrophic lesion.

In ventriculography gas is introduced directly into the lateral ventricles. This is the method of choice in patients with increased intracranial pressure. Several different types of expanding lesions occur in childhood, *i.e.*, pontine neoplasms that often cause posterior displacement of the aqueduct of Sylvius and the fourth ventricle; abscesses in the temporal region following infections of the middle ear, and in the frontal lobe, occasionally, as a result of infection of the frontal sinuses, and metastatic abscesses from such conditions as bronchiectasis.

Encephalograms and ventriculograms can be intelligently interpreted only in conjunction with other findings.

M. L. CONNELLY, M.D.

THE ESOPHAGUS

Metastases in the Esophagus. E. Proske. Strahlentherapie, **64**, 227, 1939.

Since the introduction of the protracted fractional dose method, a considerable percentage of tumors in the pharynx and larynx have been treated successfully by irradiation. A survey of this material in the Roentgen Institute at the University of Zurich revealed the fact that some of these cases died later from secondary tumors in the esophagus. They occur chiefly in patients with primary tumors of the mesopharynx, as well as the posterior hypopharynx wall. No secondary tumors of the esophagus were seen in patients with a primary malignancy of the intrinsic larynx and the epipharynx, while the occurrence was rare in patients with primary carcinoma of the mouth. In a series of 382 cases of tumors of the meso- and hypopharynx, 21 secondary neoplasms of the esophagus were observed. One was discovered before the diagnosis of a primary mesopharynx neoplasm was made. Three were seen when starting treatment of a tumor of the pharynx and all others apparently did not develop until after treatment of the primary growth had been completed. The frequency of the occurrence is estimated at about 11 per cent. No secondary neoplasms of the esophagus were seen in patients with sarcoma; it was limited to those with a primary carcinoma. In nine cases the histologic structures of primary and secondary growth were the same; in one case it differed. No relationship was found between the size of the primary tumor or the regional metastases and the occurrence of the secondary neoplasm in the esophagus. The most frequent site of the esophageal metastasis was the middle and lower third. In the majority of the cases the secondary growth occurred by implantation; lym-

phatic spread seems to be rare. While the prognosis is bad, palliative treatment by means of x-rays or radium should be applied. Since there is a possibility that biopsy favors the spread of the primary tumor, it is recommended that the endotherm method be used for procuring a specimen for histologic examination.

ERNST A. POHLE, M.D., Ph.D.

Congenital Atresia of the Esophagus. J. W. D. Bull. British Med. Jour., **2,** 983–985, Nov. 12, 1938.

The disease described is of interest in that, according to the author, it occurs more frequently than is generally believed and may, therefore, confront any diagnostician. The pathology consists mainly of a tracheobronchial fistula with an atresia just below.

The situation becomes apparent under the fluoroscope with the ingestion of barium and is verified as it progresses, with the accompanying lack of gastrointestinal function. Few of these patients live more than a week. Various surgical procedures have been suggested but the fact that the patient is nearly always the victim of other congenital lesions makes the outlook rather hopeless.

Q. B. CORAY, M.D.

Rupture of the Esophagus with Spontaneous Recovery of the Patient. Samuel Iglauer. Ann. Otol., Rhinol., and Laryngol., **47,** 1083–1088, December, 1938.

The author reports a case of rupture of the esophagus following attempted retrograde dilatation in which the patient made a spontaneous recovery. A gastrostomy had been done previously because of high-grade esophageal obstruction. After the attempted dilatation the patient had a severe reaction. X-ray examination revealed the tip of the gastrostomy tube in the posterior mediastinum and lipiodol instilled into it entered the left bronchus. The tube was left in place and this may have served for drainage of the purulent mediastinitis which developed, since the patient made a recovery without further surgical intervention.

LESTER W. PAUL, M.D.

A Case of Diverticulum of the Esophagus. M. Estève. Jour. de radiol. et d'électrol., **22,** 505, 506, October, 1938.

The author presents a case of diverticulum of the esophagus in a woman 60 years of age, complaining of the usual symptoms of this condition. X-ray examination in the oblique position showed the typical appearance of an olive-sized sac originating from the posterior wall of the esophagus at the level of the seventh cervical vertebra. The superior border was horizontal and the inferior border was convex so that it could easily be differentiated from carcinoma. The appearance was characteristic of a pulsion diverticulum and, no doubt, of congenital origin.

There is no tendency toward spontaneous healing. However, most surgeons (probably not American ones) are opposed to surgical intervention which, they feel, usually makes the condition worse. They, therefore, recommend frequent buccal lavage with antiseptic solutions and careful and thorough mastication.

Two illustrations show the condition clearly.

J. SAGEL, M.D.

FOREIGN BODIES

An Apparatus for the Localization of Foreign Bodies. P. Cottenot. Bull. et mém. Soc. de Radiol. Méd. de France, **8,** 88, 89, February, 1938.

The author has designed an apparatus which is used in conjunction with an ordinary viewing box to form a simple seriescope using but two films. By using two films taken at a given focal-film distance and a predetermined shift, it is possible to localize foreign bodies accurately and conveniently by merely reading the graduations of a scale.

S. R. BEATTY, M.D.

Radioscopic Localization of Foreign Bodies: System of Two Parallelograms. Mazérès. Bull. et mém. Soc. de radiol. méd. de France, **26,** 426–429, June, 1938.

The author describes a simple non-mathematical procedure for localizing foreign bodies. With the patient lying on the table under the screen, the tube is moved until the foreign body and its image are in the central ray and a marker is then placed on the skin at a point coinciding with the shadow of the foreign body. The tube is then rotated through an angle x, which may be any convenient angle, and moved in the direction opposite to the angle of rotation until the foreign body lies again in the principal ray. Next a cross is marked on the screen at the shadow of the foreign body, and the tube displaced further until the marker lies in the central ray. The screen is then raised vertically until the shadow of the marker and the cross coincide. The distance that the screen is raised is the distance of the foreign body below the skin marker. Sources of error are discussed and a correction factor for obliquity of the screen is derived.

S. R. BEATTY, M.D.

FRACTURES

Double Fracture of the Ribs from Coughing. Olinto Parenti. Arch. di Radiol., **14,** 318–323, 1938.

The author's patient, who had bilateral pulmonary tuberculosis, fractured two ribs by coughing, a rather unusual event.

E. T. LEDDY, M.D.

Fracture of the Neck of the Femur: A Personal Experience. John C. Nicholson. British Med. Jour., **2,** 464–466, Aug. 27, 1938.

This article is a critical analysis of the more common methods of treating fracture of the neck of the femur and it impresses one as being doubly valuable in that the author is also the patient. Due probably to the whims of "whatever gods may be," Nicholson was

forced to bear up under all four of the most generally accepted therapeutic methods, namely, sandbags, weight extension, Whitman plaster, and finally the Smith Peterson nail fixation. He comments as follows:

Sandbags.—Most painful and inefficient. Extension should be instituted at once. Nothing to recommend the old idea of rest for 24 hours.

Weight Extension.—The Steinman pin through the lower femur is most effective. Adhesive extension is most uncomfortable and leaves the skin sore. Kirschner wire through the tibia is less bothersome but causes stiffness of the knee joint.

Plaster of Paris.—The most uncomfortable, debilitating, expensive, awkward, and generally damnable method in use. The author states that he now employs the Whitman cast with his patients only as a last resort.

Radiologically Controlled Nailing.—Four weeks after this process the patient went home on crutches and could drive his own car. Seven weeks later he was again able to operate.

In conclusion, the author comments on the various arguments against the Smith Peterson nail and states that these are greatly outbalanced by the increased comfort and speed of recovery of the patient.

Q. B. CORAY, M.D.

Presentation of Radiographs. R. Guérin. Bull. et mém. Soc. de Radiol. méd. de France, **26,** 290–292, April, 1938.

A presentation of roentgenographs of a case of congenital fusion of the second and third lumbar vertebral bodies, a case of double fracture of the head and neck of the femur, and a case of fracture through the acetabulum.

S. R. BEATTY, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

The Effect of Benzedrine, Benzedrine and Atropine, and Atropine on the Gall Bladder. Purcell G. Schube, A. Myerson, and R. Lambert. Am. Jour. Med. Sci., **197,** 57–61, January, 1939.

The physiologic actions of benzedrine sulphate are due to stimulation of the sympathetic division of the autonomic nervous system, and are demonstrated in the gastro-intestinal tract by an increase in acidity and pepsinogen of the gastric juices, and a decrease in the tonus of the entire tract. The observation that paralysis of the parasympathetic system by atropine enhanced the effect of benzedrine, stimulated this investigation of the effects of these drugs, separately and in combination, on the gall bladder.

After a control cholecystographic examination, the procedure was repeated by administering each of these drugs in a new series, after which the gall bladder was again fully visualized.

The size and emptying of the gall bladder were affected very little by benzedrine alone. When atropine and benzedrine were used together, the gall bladder increased in size in a few cases. There was, however, a definite delay in the emptying, after a fatty meal. With the use of atropine alone, it was found that although no appreciable change in size took place, a very definite delay in emptying occurred after the fatty meal.

The emptying mechanism of the gall bladder is considered by Ivy to be due to direct physical or chemical stimulation of the gall-bladder wall, or by indirect stimulation through the autonomic nervous system. It appears that, generally, benzedrine delays emptying of the gall bladder only after a long period has elapsed following the administration of the drug, and that sympathetic stimulation, if it is effective, occurs only after some time. Apparently, a sympathetic stimulant and a parasympathetic paralysant together are effective in delaying gall-bladder emptying, but the effect is more marked with the parasympathetic paralysant, atropine, alone, while the sympathetic stimulant used by itself is ineffective.

BENJAMIN COPLEMAN, M.D.

Physiological Investigation of the Gall Bladder. Rosario Impallomeni. Radiol. Med., **25,** 583–596, July, 1938.

The author makes a thorough, searching investigation of the appearance of the gall-bladder shadow, its size and density. At different times he uses different methods and injects various substances intravenously, mixed with, or simultaneously with, the tetraiodophenolphthalein solution. These researches have yielded the rather interesting conclusion that when it is possible to get a rapid visualization of the gall bladder by Graham's method, this appears at the second hour, casting a small and light shadow that increases in size and opacity hourly. This observation makes one doubt the assertion that at the beginning of a cholecystographic study the gall bladder is filled and distended with bile, and leads one to think that in the method of rapid visualization of the gall bladder, based on the principle of emptying this viscus at the beginning of the test, if this is rapidly visualized it is due to a mechanism different from that following a provocative emptying.

By intravenous injection of biliary salts mixed with the tetraiodo, a more physiologic cholecystographic method is available, inasmuch as the secretion of bile is stimulated by a method somewhat similar to that excited by the normal absorption of bile from the intestine. Using this method, in normal subjects, the visualization of the gall bladder begins in 15 minutes and at the end of one hour in most of the cases, it has reached its maximum size. During the second hour, the vesicular shadow becomes intensely opaque, corresponding in size and density to that seen during the ninth or tenth hour, when using Graham's method.

Bronner's method, when used in normal subjects, shows the same efficacy as Graham's, after the second hour.

In pathological cases, when the vesicular shadow is not clear enough at the second hour, it becomes necessary to take other films during the fourth or fifth hour. One

can, thereby, bring out a slow-filling gall bladder or slow concentration of the intravesicular contents showing faulty visualization.

The last series, studied after adding to the usual dose of tetraiodo from three to four c.c. of "aminoacidi," have shown the importance of the alimentary stimulus in bile secretion during the rapid visualization of the gall bladder. With this method, an earlier visualization of the gall bladder is obtained—slow, but nevertheless faster than when the biliary salts are used.

It seems clear, therefore, that when either bile salts and aminoacids are injected simultaneously with the tetraiodo a more rapid visualization of the gall bladder is obtained than when either Bronner's or Graham's method is followed. It seems clear, also, that with these methods investigation of the power of absorption of the vesicular wall becomes roentgenologically possible.

The article is excellent but difficult to abstract. For those especially interested in the subject the reading of the article is recommended.

ANTONIO MAYORAL, M.D.

Oral Cholecystography with Divided Doses. Pawel Adamowicz. Polski Przegl. Radiol., **13,** 123–137, 1938.

The author's technic consists in the administration of four grams of the dye in the afternoon preceding the morning of the x-ray examination. In case of an unsatisfactory gall-bladder shadow, a supplementary dose of two grams of dye is given following this first x-ray examination, and further roentgenograms are taken the next afternoon and succeeding forenoon. If necessary, these examinations are complemented by fatty meals.

In the author's opinion, the radiographic results obtained by his method are equal or even superior to those achieved by means of the intravenous procedure.

ERNST A. SCHMIDT, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Acute Dilatation of the Stomach and Arterio-mesenteric Stenosis of the Duodenum. Emil Meisels. Polski Przegl. Radiol., **13,** 103–121, 1938.

Basing his conclusions on the x-ray diagnosis and clinical observation of three cases, the author discusses the principal features and etiologic factors in acute dilatation of the stomach and in arterio-mesenteric stenosis of the duodenum. He believes that, in spite of great differences in the clinical course, the two diseases should be considered a nosologic entity. To support this theory, the following common characteristics are adduced: (1) Presence of simultaneous dilatation of duodenum and stomach in cases of acute gastroplegia, and of gastric dilatation in many cases of arterio-mesenteric stenosis of the duodenum; (2) Frequent extent of the duodenal dilatation to the middle of the third portion to a point where the duodenal wall is crossed by the mesenteric pedicle; (3) Sharp and distinct delineation from the small intestine below (which is narrow and almost empty), and (4) In the majority of cases, absence of lesions which might explain the mechanical pathogenesis of the stenosis.

Concerning the mechanism of the obstruction, different theories are dealt with in detail: the original Rokitansky-Albrecht explanation of direct compression by the mesenteric artery, the later explanation of American and French authors (Codman, Bloodgood, Duval, and others) emphasizing diminution of the arterio-aortic angle due to traction and ptosis, and, finally, the theory of functional neuro-muscular disturbances, either due to reflex action or to neuropathic hypersensibility toward certain agents (*e.g.*, toxic agents after narcosis).

The author calls attention to analogies with the idiopathic dilatation of the esophagus which must be considered the result of disturbances in the neuromuscular system regulating deglutition.

ERNST A. SCHMIDT, M.D.

The Diagnostic Value of a Plain Roentgen Study of the Abdomen. Heinrich Müller. München. med. Wchnschr., **85,** 1999–2001, Dec. 23, 1938.

The author routinely makes a plain study of the chest and abdomen before every gastro-intestinal series and barium enema. He points out that much valuable information may thus be gained. Cases of kidney stone, gallstone, calcified kidney, and abdominal cystoma are reported, and the diagnoses of enlargement of the gall bladder, mesenteric cyst, traumatic pancreatic cyst, abscess, perforated ulcer, ileus, encapsulated effusion, liver abscess, and acute pancreatic necrosis are briefly discussed. It is felt that this procedure is of great diagnostic worth.

LEWIS G. JACOBS, M.D.

Chronic Gastritis. Serse Zanetti and G. Guerreri D'Antona. Radiol. Med., **25,** 945–966, November, 1938.

This is a very complete article. The authors review the different historical epochs in diagnosis, beginning with the early work of Morgagni who, in the eighteenth century demonstrated the presence of ulcerations in the mucosa. This was followed, in rapid succession, by the era of chemical examination of gastric juice, of Ewald and Boas; anatomical-clinical of Hayem; surgical of the Mayos, Robson, and of Moynihan; then the radiological era, and now the new and relatively recent use of the flexible gastroscope. Special emphasis is given to the work of Forssell who has so conclusively demonstrated the autonomous power of motility of the mucosa of the gastro-intestinal tract, and its ability to assume distinct patterns to conform with the necessities of digestion.

The work is based on nearly six hundred cases of recovered ulcer patients. On these, 250 resections were done, and the conclusions are derived from the clinical, pathologic, and radiologic studies of this vast number of cases. The authors call attention to the lack of

pathognomonic symptoms in gastritis, and to the fact that gastritis and ulcer are always found to be co-existent. Although this is true, they believe it unwise to affirm that all the symptoms of one condition are due to the presence of the other. After studying the resected specimens, however, one could not feel disposed to make an absolute denial that ulcer symptoms, whether gastric or duodenal, are due to the co-existing gastritis. When, however, dealing with those cases presenting atypical symptomatology, these may be due to allied lesions. On the other hand, when the patient presents the classical symptoms of ulcer it is always chronic (ulcers of Cruveilhier), the mucosal lesions showing a marked tendency toward chronicity and atrophy. The authors conclude by stating that the more marked or the more advanced the gastritis, the more difficult the clinical diagnosis of ulcer, whether gastric or duodenal.

The value of roentgenologic examination of the stomach, when done by small feedings, needs no emphasis and these authors plead for a closer co-operation between the surgeon and the radiologist in studying each other's work, especially the latter, who should make a careful inspection of all resected specimens before they are fixed, in order to help him conceive an exact picture of the living organ.

In making the radiological examination, the following absolute rules should be followed: a complete emptying of the stomach and perfect roentgenograms. To obtain these results, a technic rapid enough to stop motion should be used. A clean colon and well-aimed rays are essential in obtaining good patterns of the mucosa.

Acute gastritis presenting no characteristic mucosal alterations is not suitable for x-ray diagnosis; the references herein contained are, therefore, concerning chronic gastritis.

The radiologic differential diagnosis of chronic gastritis is based on the anatomic-pathologic changes taking place in the mucosa. They are classified as atrophic or hypertrophic, both types being not infrequently co-existent.

Hypertrophic gastritis is recognized by the increase in size of the rugæ, these being decreased in number, but increased in length, while their elasticity is greatly reduced. They follow a very irregular course, being straight or serpentigenous. In advanced cases, the mucosal pattern may become completely disorganized. When the site of the lesion is the fundus of the stomach, the diagnosis is extremely difficult and at times impossible. The hypertrophy of the rugæ is maintained by an abnormal serous absorption by the gastric wall, the action being especially evident in the submucosa.

The atrophic type is characterized by less prominent rugæ which follow an almost normal course. At times, however, there is a complete disappearance of mucosal pattern, the lesion being generally limited in distribution, except in cases of chemical gastritis. The gastric region most commonly affected is the fundus, but based on roentgenologic investigation, it must be said that atrophic gastritis presents a queer distribution. Nevertheless, caution should be exercised by the roentgenologist in diagnosing this type of lesion, as there are many other conditions that can simulate the mucosal relief. When, however, both types, as often happens, are found in the same stomach, the mucosal pattern assumes a characteristic radiologic picture. To the long serpentigenous and rigid rugæ, seen in polypoid gastritis, are associated almost imperceptible rugæ, or, frequently, there is complete absence of mucosal folds, the marking seen in the film of the gastric region simulating the color streaks seen in a piece of polished marble, or they may be a uniformly opaque blotch, the opacity at the edges blending gradually with the surrounding shadows.

This description of the main radiological signs of gastritis is followed in this article by timely and useful observations on ulcerative gastritis and finishes with the following sentence: "We repeat the necessity of exercising great care in making a diagnosis of ulcerative gastritis: this should be made only after very accurate and painstaking examinations."

In the opinion of the authors, the radiologic examination should not be limited to diagnosis as it also has a great prognostic value. When the mucosa is greatly inflamed, the inflammation is also extensive and contra-indicates surgical intervention, as greatly inflamed tissue offers bad post-operative risk. A well and carefully conducted radiologic investigation, which shows an exact picture of the internal relief of the stomach, will inform the surgeon of the condition of the mucosa and also assist him in deciding for or against intervention.

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